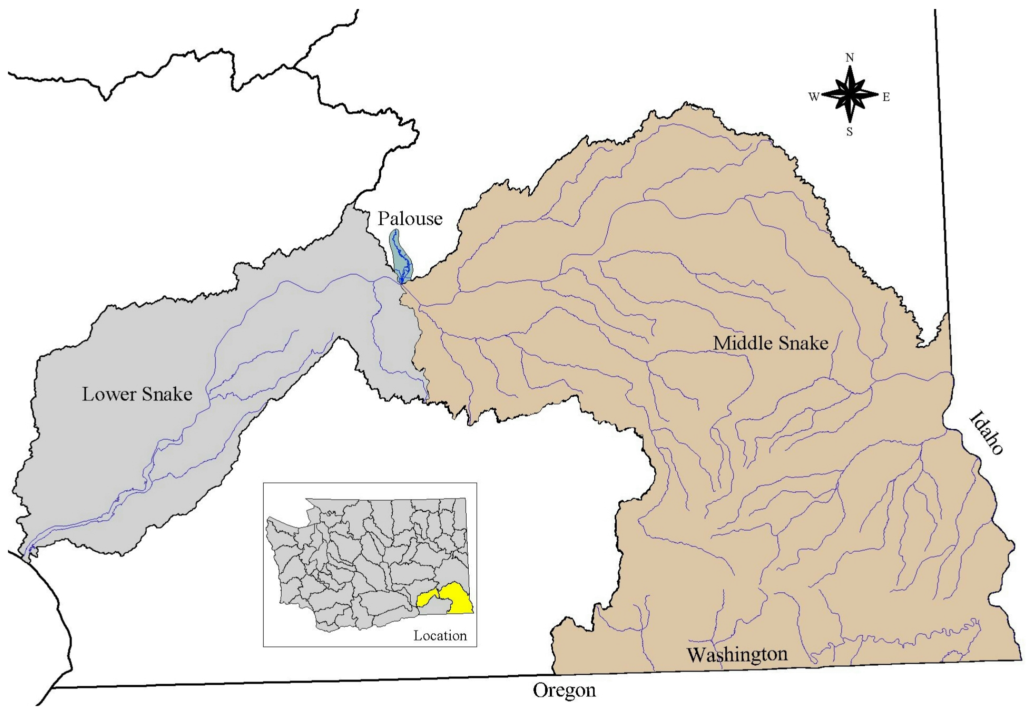
Washington State Conservation Commission

SALMONID HABITAT LIMITING FACTORS WATER RESOURCE INVENTORY AREAS 33 (LOWER) & 35 (MIDDLE) SNAKE WATERSHEDS, & LOWER SIX MILES OF THE PALOUSE RIVER



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ABBREVIATIONS AND ACRONYMS

ACCD: Asotin County Conservation District
BPA: Bonneville Power Administration
BOR: Bureau of Reclamation
CTUIR: Confederated Tribes of the Umatilla Indian Reservation
CCD: Columbia Conservation District
CFS: Cubic Feet per Second
CREP: Conservation Reserve Enhancement Program
CRP: Conservation Reserve Program
DEQ: Oregon Department of Environmental Quality
DO: Dissolved Oxygen
DOE: Washington Department of Ecology
EQIP: Environmental Quality Incentives Program
ESA: Endangered Species Act
FLIR: Forward Looking Infrared Radiometry (infrared photography)
FSA: Farm Service Agency (USDA)
ICBEMP: Interior Columbia Basin Ecosystem Management Project
IFIM: Instream Flow Incremental Methodology
LB: Left Bank of stream (looking downstream)
LWD: Large Woody Debris
NRCS: USDA Natural Resource Conservation Service (formerly SCS)
NMFS: National Marine Fisheries Service
NWPPC: Northwest Power Planning Council
ODFW: Oregon Department of Fish and Wildlife
OWRD: Oregon Water Resources Department
PCD: Pomeroy Conservation District
RB: Right Bank of stream (looking downstream)
RM: River Mile
SCS: USDA Soil Conservation Service (now NRCS)
SRFB: Washington State Salmon Recovery Funding Board
TSS: Total Suspended Solids
USACE: United States Army Corps of Engineers
USDA: United States Department of Agriculture
USFS: United States Forest Service
USFWS: United States Fish and Wildlife Service
WAC: Washington Administrative Code
WCC: Washington State Conservation Commission
WDFW: Washington Department of Fish and Wildlife
WHIP: Wildlife Habitat Incentives Program
WRIA: Water Resource Inventory Area

EXECUTIVE SUMMARY

This report describes and assesses salmonid habitat in tributary streams of the Snake River, within Washington. Water Resource Inventory Areas (WRIA) 33 (Lower Snake), 34 (Palouse), and 35 (Middle Snake) are examined, although WRIA 35 is the focus of the report. Salmonid habitat limiting factors reports as described in Revised Code of Washington (RCW) 77 are intended to describe and assess salmonid habitat in tributary streams. For this reason, the mainstem lower Snake River will not be evaluated with the exception of a discussion of fish passage issues through the four lower Snake River dams and reservoirs (Ice Harbor Dam at RM 10, Lower Monumental Dam at RM 42, Little Goose Dam at RM 70, and Lower Granite Dam at RM 107). This report examines salmonid habitat only. No attempt has been made to evaluate hydropower, harvest, or hatchery issues. These important factors in the decline of anadromous salmonids in the lower Snake River are being dealt with by other entities. The report is a summary of existing knowledge from both published and unpublished literature and data and interviews of people with technical expertise in the region. It is intended for use in prioritization of salmonid habitat restoration projects. It is not a recovery plan for Snake River salmonid populations, although it could be a component of such a plan. Habitat conditions are described, then assessed based on standards developed from published sources and consultations with local natural resource agency personnel. An attempt is made to identify the causes of habitat degradation. Finally, recommendations are made to protect currently functional habitat as well as restore degraded habitat.

Water Resource Inventory Areas 33 and 35 drain about 722 and 2,250 square miles of southeast Washington respectively. The Palouse River is only examined from the mouth upstream to 185-feet high Palouse Falls, a very small area in relation to the other two basins. Climate in this portion of the state is generally arid to semi-arid in the summer and early fall. Winters are generally cold with moderate snowfall at low elevations and substantial snowfall in the forested Blue Mountains. Basalt flows covered by a blanket of highly erodible loess soil are the dominant geologic feature of the region. Folding and faulting of bedrock and downcutting of streams have created numerous deep canyons throughout the drainage network (Alt and Hyndman 1998).

The four lower Snake River Dams have changed the majority of the Snake River within Washington from a wild and unpredictable river to a series of four highly managed reservoirs (WRIAs 33 and 35). Listing of salmonids under the Endangered Species Act (ESA) began in 1991 with the endangered listing of sockeye from Idaho's Salmon River Basin. Today the Snake River is primarily a migration corridor for sockeye; as well as ESA threatened spring chinook, steelhead, and bull trout (National Marine Fisheries Service 1991, National Marine Fisheries Service 1992, Fish and Wildlife Service 1998, National Marine Fisheries Service 1999). Historically fall chinook spawning in the Washington portion of the Snake River was concentrated near the mouths of the Palouse and Clearwater Rivers (Fulton 1968, cited in Dauble 2000). However, the majority of fall chinook spawning took place much higher in the watershed prior to construction of numerous dams from Hells Canyon upstream (Dauble 2000). The majority of mainstem fall chinook spawning occurs in the free-flowing reach still remaining from Hells Canyon Dam downstream to the City of Asotin, WA. Limited fall chinook spawning also occurs in the tailraces of the four lower Snake River dams, and the lower portions of the Grande Ronde and Tucannon Rivers in Washington and the lower Clearwater River in Idaho (TAG 2001, personal communication). Fall chinook juveniles rear throughout the lower Snake

River (Dauble 2000). Fall chinook are listed as ESA threatened (National Marine Fisheries Service 1992).

Land use impacts associated with dryland agriculture, logging, flood control, concentrated recreational use of public lands, rural and recreational development, roads, and to a lesser extent irrigated agriculture have had significant negative effects on salmonid habitat in Snake River tributary streams (WRIA 35). Conversion of floodplains and riparian forest buffers to agricultural fields and residences, and channel modifications including straightening, diking, and bank armoring have dramatically altered the lower portions of the Tucannon River and Asotin Creek as well as smaller systems such as Alpowa and Deadman Creeks. Logging, conversion of perennial grasslands to annually planted dry cropland, and grazing have led to increased runoff and erosion of fine sediment throughout the region.

Habitat conditions are generally fair to poor on private lands in the lower portions of watersheds. Mid-elevation reaches are generally in fair condition, with patches of degradation. Conditions on public lands in headwater areas, particularly the Wenaha-Tucannon Wilderness Area are generally fair to good. Unfortunately headwater streams drain very steep portions of the Blue Mountains. The geology of these areas leads to naturally low numbers of pools and limited spawning gravel. The largest pools and significant levels of spawning gravel are generally found in the middle or lower portions of the watersheds where alterations of stream channels, removal of riparian vegetation, and surface water withdrawals (which exacerbate naturally low summer stream flows) have combined to increase water temperatures above the tolerance levels of salmonids. Fine sediment deposition is also a problem in these low gradient stream reaches. However, habitat restoration efforts have been taking place since the mid-1990s, largely beginning with the development of “Model Watershed Plans” for the Asotin Creek, Tucannon River, and Pataha Creek watersheds. Many entities and funding sources have partnered in habitat restoration and/or improvement projects on Snake River tributary streams in WRIA 35.

WRIAS 33, 34, 35 RECOMMENDATIONS

Protect existing relatively high quality salmonid habitat on public lands and small patches that remain on private lands. This includes stream reaches that currently exhibit one or more of the following desirable features: natural sinuosity, functional floodplains, riparian forest buffers, abundant large woody debris, large and deep pools with instream or overhead cover, clean spawning substrate, sufficient summer stream flows, and cold summer water temperatures; or currently support salmonid populations.

On developed or modified stream reaches restore "normative" river function through dike removal or setback, removal of bank armoring, meander reconstruction (increase sinuosity), and riparian forest buffer restoration.

In the short term, improve instream habitat through large woody debris placement, pool construction, and riparian plantings in limited locations specified by technical experts. Reliance on instream projects should be minimized since they largely treat symptoms, rather than addressing the root cause(s) of habitat degradation.

In the long term, reduce summer stream temperatures, improve bank and channel stability, and increase large woody debris abundance by reestablishing riparian forest buffers along all streams where forests were historically present.

Practice proper riparian vegetation management to ensure healthy vigorous plant growth of woody vegetation and natural regeneration. Best management practices (BMPs) could include, but are not limited to: limited riparian "flash grazing," pasture rotation, fencing livestock out of streams and riparian areas, and development of off-site watering facilities.

Reduce erosion of fine sediment by implementing no-till/direct seed farming methods on as many acres as possible. Implement other BMPs including riparian forest buffers, grassed waterways, terraces, sediment basins, and the Conservation Reserve Program (CRP) where appropriate. Continue education and cost share programs to encourage conversion to no-till/direct seed farming.

Enhance summer stream flows through water lease and/or purchase or irrigation efficiency improvements. Conversion of conventionally tilled acreage to no-till/direct seed may improve stream flows through increased water infiltration to aquifers where it will be released gradually to streams. Enforce existing water laws.

Inventory all surface water diversions (both legal and illegal). Screen all diversions to state and federal criteria and halt operation of illegal diversions.

Enforce existing land use regulations including Critical Area Ordinances, Shoreline Management Act, and the Growth Management Act.

Reduce and/or eliminate further floodplain development. Where possible restore floodplain function on reaches that were modified in the past.

Inventory habitat conditions as well as fish presence and relative abundance on southeast Washington streams every five years to fill data gaps and monitor success of habitat restoration projects. Conduct continuous monitoring of water quality parameters such as water temperature and total suspended solids.

Update this report within a three to five year period to replace TAG information with data collected during the inventories recommended previously.

Table 1. Middle Snake Watershed Landmarks.

Landmark	*Note: All distances measured from the mouth of receiving stream. Orientation (looking downstream) LB = Left Bank, RB = Right Bank*	**River Mile**[1]
Snake River		
Ice Harbor Dam		10
Lower Monumental Dam		42
Tucannon River (LB)		62.2
Alkali Flat Creek (RB)		67
Little Goose Dam		70
Meadow Creek (LB)		82.7
Deadman Creek (LB)		82.7
Penawawa Creek (RB)		91.6
Almota Creek (RB)		102.8
Lower Granite Dam		107
Wawawai Creek (RB)		110.5
Steptoe Creek (RB)		128.2
Alpowa Creek (LB)		130.6
Clarkston (LB)		139
Asotin Creek (LB)		145.3
Tenmile Creek (LB)		150.3
Couse Creek (LB)		157.6
Grande Ronde River (LB)		168.7
Washington/Oregon Stateline		176
Grande Ronde River		
Joseph Creek (RB)		4.3
Schumaker Creek (LB)		15.7
Deer Creek (RB)		19.3
Buford Creek (RB)		25.7
Rattlenake Creek (LB)		26.2
Cottonwood Creek (LB)		28.7
Bear Creek (RB)		30.2
Cougar Creek (LB)		30.7
Menatchee Creek (LB), also "Wenatchee Creek"		35.9
Washington/Oregon Stateline		38.2

1. River mile information from: (Washington Department of Fish and Wildlife 1975, unpublished work, Washington State Conservation Commission and Northwest Indian Fisheries Commission 2001, unpublished work)

Table 1. Continued.

Landmark	**River Mile**
Asotin Creek	
George Creek (RB)	3.1
Pintler Creek (RB)	0.7
Wormell Creek (RB)	13.7
Coombs Creek (RB)	16.2
Charley Creek (LB)	13.5
Confluence of North and South Forks	14.9
U.S. Forest Service Boundary (Charley Creek)	6.6
U.S. Forest Service Boundary (N.F. Asotin Creek)	4.6
U.S. Forest Service Boundary (S.F. Asotin Creek)	7.9
U.S. Forest Service Boundary (George Creek)	18.2
Deadman Creek	
Confluence of North and South Forks	12.3
Meadow Creek	
Confluence of North and South Forks	13.6
Tucannon River	
Starbuck	4
Pataha Creek (RB)	12
Marengo (RB)	25
Wooten Wildlife Area Boundary (1st bridge below Hartsock Grade)	30.1
Tumalum Creek (RB)	32.1
Cummings Creek (RB)	34.2
U.S. Forest Service Boundary (includes Wooten inholdings)	37.0
Little Tucannon River (LB)	43.9
Panjab Creek (LB)	45.8
Cold Creek (LB)	50
Sheep Creek (RB)	50.4
Bear Creek (LB)	54
Pataha Creek	
Dodge	10
Pomeroy	21.7
Columbia Center	37.3
U.S. Forest Service Boundary	42.6

INTRODUCTION

How to Use This Document

This report is made available in a digital format known as portable document format (pdf). This allows anyone with a computer (regardless of platform) and free Adobe Acrobat Reader 5.0 (or greater) software to read and print the document. If you are reading the report on your computer you can take advantage of features commonly found on web pages. The Acrobat software allows you to search for your topic of interest. You will notice blue underlined text throughout the document. These hyperlinks will take you directly to maps included with the report. Cross-references to tables and figures may also be clicked to take you directly to the referenced item. You may view maps and the report simultaneously by manually opening a map from the CD-ROM (located in folder named PDF_Maps) while you are reading the narrative. Adobe Acrobat Reader is available at: http://www.adobe.com/products/acrobat/readstep.html.

Salmonid Habitat Limiting Factors Background

The successful recovery of naturally spawning salmon populations depends upon directing actions simultaneously at harvest, hatcheries, habitat and hydro, the 4H's. The 1998 state legislative session produced a number of bills aimed at salmon recovery. Engrossed Substitute House Bill (ESHB) 2496 *(later codified to RCW 77)* was a key piece of the 1998 Legislature's salmon recovery effort, with the focus directed at salmon habitat issues.

Engrossed Substitute House Bill (ESHB) 2496 in part:

- Directs the Conservation Commission in consultation with local government and the tribes to invite private, federal, state, tribal and local government personnel with appropriate expertise to act as a technical advisory group;
- Directs the technical advisory group (TAG) to identify limiting factors for salmonids to respond to the limiting factors relating to habitat pursuant to section 8 sub 2 of this act;
- Defines limiting factors as "conditions that limit the ability of habitat to fully sustain populations of salmon;"
- Defines salmon as all members of the family salmonidae, which are capable of self-sustaining, natural production.

The overall goal of the Conservation Commission's limiting factors project is to identify habitat factors limiting production of salmon in the state. It is important to note that the responsibilities given to the Conservation Commission in ESHB 2496 do not constitute a full limiting factors analysis. The hatchery, hydropower, and harvest limiting factors are being dealt with in other forums.

The Relative Role of Habitat in Healthy Populations of Natural Spawning Salmon (Chapter Author — Carol Smith, PhD, edited by the report Author)

During the last 10,000 years, Washington State Anadromous salmonid populations have evolved in their specific habitats (Miller 1965). Water chemistry, flow, and the physical stream components unique to each stream have helped shape the characteristics of every salmon population. These unique physical attributes have resulted in a wide variety of distinct salmon stocks for each species throughout the state. Within a given species, stocks are population units that do not extensively interbreed because returning adults rely on a stream's unique chemical and physical characteristics to guide them to their natal grounds to spawn. This maintains the separation of stocks during reproduction, preserving the distinctiveness of each stock.

Throughout the salmon's life cycle, the dependence between the stream and a stock continues. Adults spawn in areas near their own origin because survival favors those that do. The timing of juveniles leaving the river and entering the estuary is tied to high natural river flows. It has been theorized that the faster speed during outmigration reduces predation on the young salmon and perhaps is coincident to favorable feeding conditions in the estuary (Wetherall 1971). These are a few examples that illustrate how a salmon stock and its environment are intertwined throughout the entire life cycle.

Salmon habitat includes the physical, chemical and biological components of the environment that support salmon. Within freshwater and estuarine environments, these components include water quality, water quantity or flows, stream and river physical features, riparian zones, upland terrestrial conditions, and ecosystem interactions as the pertain to habitat. However, these components closely intertwine. Low stream flows can alter water quality by increasing temperatures and decreasing the amount of available dissolved oxygen, while concentrating toxic materials. Water quality can impact stream conditions through heavy sediment loads, which decrease spawning success. The riparian zone interacts with the stream environment, providing nutrients and a food web base and woody debris for habitat and flow control. It also filters runoff prior and shades the stream to aid in water temperature control.

Salmon habitat includes clean, cool, well-oxygenated water flowing at a normal (natural) rate for all stages of freshwater life. In addition, salmon survival depends upon specific habitat needs for egg incubation, juvenile rearing, migration of juveniles to saltwater, estuary rearing, ocean rearing, adult migration to spawning areas, and spawning. These specific needs can vary by species and even by stock.

When adults return to spawn, they not only need adequate flows and water quality, but also unimpeded passage to their spawning grounds. They need deep pools with vegetative cover and instream structures such as root wads for resting and shelter from predators. Successful spawning and incubation depend on sufficient gravel of the right size for that particular population, in addition to the constant need of adequate flows and water quality, all in unison at the necessary location. Also, delayed upstream migration can be critical. After entering freshwater, most salmon have a limited time to migrate and spawn, in some cases, as little as 2-3 weeks. Delays can result in pre-spawning mortality, or spawning in a sub-optimum location.

After spawning, the eggs need stable gravel that is not choked with sediment. River channel stability is vital at this life history stage. Floods have their greatest impact to salmon populations during incubation, and flood impacts are worsened by human activities. In a natural river system, the upland areas are forested, and the trees and their roots store precipitation, which slows the rate of storm water runoff into the stream. The natural, healthy river is sinuous and contains large pieces of wood contributed by an intact, mature riparian zone. Both slow the speed of water downstream. Natural systems have floodplains that are connected directly to the river at many points, allowing wetlands to store flood water and later discharge this storage back to the river during low flows. In a healthy river, erosion or sediment input is great enough to provide new gravel for spawning and incubation, but does not overwhelm the system, raising the riverbed and increasing channel instability. A stable incubation environment is essential for salmon, but is a complex function of nearly all habitat components contained within that river ecosystem.

Once the young fry emerge from the gravel nests, certain species such as chum, pink, and fall chinook salmon quickly migrate downstream to the estuary. Other species such as coho, steelhead, bull trout, and spring chinook will search for suitable rearing habitat within the side sloughs and channels, tributaries, and spring-fed “seep” areas, as well as the outer edges of the stream. These quiet-water side margin and off-channel slough areas are vital for early juvenile habitat. Woody debris and overhead cover provide protection from predators and habitat for forage species. Most juvenile salmonids use this type of habitat in the spring.

As growth continues, the juvenile salmon (parr) move away from the quiet shallow areas to deeper, faster areas of the stream. These include coho, steelhead, bull trout, and spring chinook. For some of these species, this movement is coincident with the summer low flows. Low flows constrain salmon production for stocks that rear within the stream. In non-glacial streams, summer flows are maintained by precipitation, connectivity to wetland discharges, and groundwater inputs. Reductions in these inputs will reduce habitat; hence, the number of salmon dependent on adequate summer flows.

In the fall, juvenile salmon that remain in freshwater begin to move out of the mainstems, and off-channel habitat again becomes important. During the winter, coho, steelhead, bull trout, and remaining chinook parr require habitat to sustain their growth and protect them from predators and winter flows. Wetlands, stream habitat protected from the effects of high flows, and pools with overhead cover are important habitat components during this time.

Except for bull trout and resident steelhead (rainbow/redband trout), juvenile parr convert to smolts as they migrate downstream toward the estuary. Again, flows are critical, and food and shelter are necessary. The natural flow regime in each river is unique, and has shaped the population’s characteristics through adaptation over the last 10,000 years. Because of the close inter-relationship between a salmon stock and its stream, survival of the stock depends heavily on natural flow patterns.

The estuary provides an ideal area for rapid growth, and some salmon species are heavily dependent on estuaries, particularly chinook, chum, and to a lesser extent, pink salmon. Estuaries contain new food sources to support the rapid growth of salmon smolts, but adequate natural habitat must exist to support the detritus-based food web, such as eelgrass beds, mudflats, and salt marshes. In addition, the processes that contribute nutrients and woody debris to these environments must be maintained to provide cover from predators and to sustain the food web. Common disruptions to these habitats include dikes, bulkheads, dredging and filling activities, pollution, and alteration of downstream components such as a lack of woody debris and sediment transport.

All salmonid species need adequate flow and water quality, spawning riffles and pools, a functional riparian zone, and upland conditions that favor stability, but some of these specific needs vary by species, such as preferred spawning areas and gravel. Although some overlap occurs, different salmon species within a river are often staggered in their use of a particular type of habitat. Some are staggered in time, and others are separated by distance.

Chinook Salmon Life History

Chinook salmon *(Oncorhynchus tshawytscha)* have three major run types in Washington State. Juvenile spring chinook are generally in their natal rivers throughout the calendar year. Adults begin river entry in May or early June. Spring chinook spawn from July through September, typically in headwater areas where higher gradient habitat exists. Incubation continues throughout the autumn and winter, and generally requires more time for the eggs to develop into fry because of the colder temperatures in the headwater areas. Fry begin to leave the gravel nests in February through early March. The juveniles of spring chinook salmon stocks in the Columbia Basin exhibit some distinct life history characteristics. Generally, these stocks remain in the basin for a full year. However, some stocks migrate downstream from their natal tributaries in the fall and early winter into larger rivers, including the Columbia, where they are believed to over-winter prior to outmigration the next spring as yearling smolts.

Adult summer chinook begin river entry as early as June in the Columbia. They generally spawn in September and/or October. Fall chinook stocks range in spawn timing from late September through December. All Washington summer and fall chinook stocks have juveniles that incubate in the gravel until January through early March. Outmigration downstream to the estuaries occurs over a broad period (January through August). A few of these stocks have a component of juveniles that remain in freshwater for a full year after emerging from the gravel nests.

While some emerging chinook salmon fry outmigrate quickly, most inhabit the shallow side margins and side sloughs for up to two months. Then, some gradually move into the faster water areas of the stream to rear, while others outmigrate to the estuary. Most summer and fall chinook outmigrate within their first year of life, but a few stocks (Snohomish summer chinook, Snohomish fall chinook, and upper Columbia summer chinook) have juveniles that remain in the river for an additional year, similar to many spring chinook (Marshall *et al.* 1995). However, those in the upper Columbia, have scale patterns that suggest that they rear in a reservoir-like environment (mainstem Columbia upstream from a dam) rather than in their natal streams and it is unknown whether this is a result of dam influence or whether it is a natural pattern.

As they grow, juvenile salmonids move into faster water and disperse into tributaries and areas which adults cannot access (Neave 1949). Pool habitat is important not only for returning adults, but for all stages of juvenile development. Quality pool habitat includes deep pools with overhanging riparian cover, large woody debris, and large cobble/boulder substrate.

Steelhead/Rainbow Trout Life History

Steelhead *(Oncorhynchus mykiss)* have the most complex life history patterns of any Pacific salmonid species (Shapovalov and Taft 1954). In Washington, there are two major run types, winter and summer steelhead. Winter steelhead adults begin river entry in a mature reproductive state in December and generally spawn from February through May. Summer steelhead adults enter the river from about May through October with spawning from about February through April. They enter the river in an immature state and require several months to mature (Burgner *et al.* 1992). Summer steelhead usually spawn farther upstream than winter stocks (Withler 1966) and dominate inland areas such as the Columbia Basin. However, the coastal streams support more winter steelhead populations.

Juvenile steelhead can either migrate to sea or remain in freshwater as rainbow or redband trout. In Washington, those that are anadromous usually spend 1-3 years in freshwater, with the greatest proportion spending two years (Busby *et al.* 2000). Because of this, steelhead rely heavily on freshwater habitat and are present in streams all year long.

Bull Trout Life History

Bull trout *(Salvelinus confluentus)* are also very dependent on the freshwater environment, where they reproduce only in clean, cold, relatively pristine streams. Bull trout exhibit a complex life history that includes three possible strategies. Resident fish stay in the natal stream their entire life. Fluvial fish migrate (as juveniles) from the natal stream to a larger river, and adfluvial juveniles migrate upstream or downstream to a lake or reservoir. These last two strategies are utilized to take advantage of increased food supplies, similar to anadromous salmonid maturation in the ocean. Adult bull trout return to the natal stream to spawn (Goetz 1989). Bull trout reproduce slowly because of a four to seven year sexual maturation period. They are a long-lived fish, with some known to live up to twelve years (Fish and Wildlife Service 1998). In the fall, they spawn in cold streams with clean gravel and cobble substrates on gentle gradients. Eggs hatch in late winter to early spring about four to five months after egg deposition. Fry hide in the substrate for several weeks prior to emergence (swimming up out of the gravel), at which time they continue to stay close to the bottom (Goetz 1989).

In addition to the above-described relationships between various salmon species and their habitats, there are also interactions between the species that have evolved over the last 10,000 years such that the survival of one species might be enhanced or impacted by the presence of another. Pink and chum salmon fry are frequently food items of coho smolts, dolly varden, and steelhead (Hunter 1959). Chum fry have decreased feeding and growth rates when pink salmon juveniles are abundant (Ivankov and Andreyev 1971), probably the result of occupying the same habitat at the same time (competition). These are just a few examples. Most streams in Washington are home to several salmonid species, which together, rely upon freshwater and estuary habitat the entire calendar year. As the habitat and salmon review have indicated, there are complex interactions between different habitat components, between salmon and their habitat, and between different species of salmon. For just as habitat dictates salmon types and production, salmon contribute to habitat and to other species.

WATERSHED HISTORY

Native American Tribes and early Euro-American Exploration

Native American tribes were the first inhabitants of southeast Washington. The Nez Perce, Cayuse, and Umatilla tribes grazed horses in the river bottoms and high meadows of southeast Washington prior to European settlement (Columbia Conservation District 1997). American Indians have inhabitated the Snake River Canyon for the last 7,100 to 10,000 years. The Nez Perce called the canyon home and were frequently visited by the Shoshone-Bannock, Northern Paiute, and Cayuse Indians (Northwest Power Planning Council 2001d). Couse and Tenmile Creeks were an important travel route for the Nez Perce moving between the Snake River and hunting grounds in the Grande Ronde Watershed (Northwest Power Planning Council 2001a). Lewis and Clark passed through the region in 1805 and 1806. They canoed down the Clearwater River of Idaho and arrived at the Snake River on October 10, 1805 at the present sites of Lewistown, Idaho and Clarkston, Washington. Vegetation along the banks of the Snake River and tributary mouths consisted primarily of willows and small shrubs. The explorers described the banks as "destitute of any kind of timber (Coues 1893, pg. 628)." In 1806 the Lewis and Clark Expedition followed an over land route through southeast Washington on the return trip to St. Louis. The route began at the Walla Walla River, turned up the Touchet River and Patit Creek, crossed over into the Tucannon valley, then followed Pataha Creek to Alpowa summit, and finally followed Alpowa Creek to the Snake River (Coues 1893). The Tucannon River was described as follows May 3, 1806:

> .... though only 12 yards wide discharges a considerable body of water into Lewis' [the Snake] river, a few miles above the narrows. Its bed is pebbled, its banks are low, and the hills near its sides high and rugged; but in its narrow bottoms are found some cottonwood, willow, and the underbrush which grows equally on the east branch of the Wollawollah [Touchet River] (Coues 1893, pg. 983).

The expedition found little timber along Pataha Creek (Coues 1893), but Pataha means "brushy creek" (Bartels 2002, personal communication) which suggests that willows and other shrubs must have been relatively common along the stream. The Native American tribes continued occupation of these lands and developed a trade system with British fur traders.

The Fur Trade

The northwest fur trade began to develop soon after completion of the Lewis and Clark Expedition. By the 1820s, the Hudson's Bay Company had secured a monopoly on the Columbia Plain. The tribes trapped beaver for the fur companies and traded furs for British goods. At that time, the area was largely untapped fur country with immense beaver populations as evidenced by the 1822-23 harvest of almost 20,000 beaver and otter. By 1824 the Columbia region was the greatest fur producer of all the Hudson's Bay Company holdings — stretching from the Atlantic Ocean to the Pacific Ocean and North to the Arctic Ocean (Meinig 1968). The company had an insatiable appetite for furs. Returns from the Snake River region (of which the vast majority falls outside of WRIA 35) averaged 2,550 beaver per year from 1826 to 1830, but plummeted to an average of 654 per year from 1846 to 1850. The fur trade effectively ended in 1850 (Meinig 1968).

American Settlement

Missions were established in the fall of 1836 by Marcus Whitman near Walla Walla and Henry Spalding at Lapwai (tributary of the Clearwater River, Idaho) (Meinig 1968). Henry Spalding and his Nez Perce converts established commerce in southeast Washington in the 1830s when they established a grain field, apple orchard, and gristmill at Alpowa (Kamimura and Froyalde 2000a). The attempted rapid conversion of the subsistence based Native American culture to an agricultural based Christian culture along with rampant deaths of tribal members caused by European diseases led to unrest in the tribes. Small battles broke out periodically between 1847 and 1858. Territorial Governor Isaac Stevens negotiated treaties with the tribes in 1855 (Meinig 1968). The Snake River Canyon has extreme cultural significance to the Nez Perce Tribe and is located entirely within the lands ceded to the United States in the Treaty of 1855. The Nez Perce maintain the right to fish, gather roots and berries, hunt, and graze livestock (Northwest Power Planning Council 2001d). Once fighting had stopped in late 1858, the way was cleared for American expansion into the region. Congress ratified the tribal treaties in 1859, forming the Yakima, Umatilla, and Nez Perce Reservations (Meinig 1968). Discovery of gold on the upper Clearwater River (Meinig 1968) and the Snake River in 1860 encouraged settlement of the region. Placer mining left hundreds of rock piles littered along the Snake River (Northwest Power Planning Council 2001d). The city of Lewiston, Idaho was founded in the fall of 1861 (Meinig 1968).

<u>Asotin County</u>
The first permanent white settler, Sam Smith arrived in Asotin County (Washington Territory) in June 1861. He built a general store and hotel near Alpowa that catered to prospectors on their way to Idaho. Settlers also began to take up residence near Asotin (a former Nez Perce village, as was Alpowa). By 1868, farmers were producing cattle, fruit, and vegetables to feed miners in Idaho. Asotin County was established in 1883. Additional immigrants arrived attracted by incorporation of the county. By 1888, Asotin had hotels, a drug store, saloons, a laundry, livery stables, and blacksmiths. Anatone was platted in 1878. The town served as the hub of commerce for farmers in the nearby Grande Ronde Valley. Lewiston, Washington was platted in 1896. It was seen as an extension of Lewiston, Idaho. In 1901, the Washington State Legislature changed the name of the town to Clarkston to give equal honor to both leaders of the Lewis and Clark Expedition. By the early 1900s, the Clarkston-Vineland area was famous for production of strawberries, raspberries, blackberries, cherries, and peaches. Pears, apricots, apples, and nuts were added to the existing fruit production that was largely concentrated on the Snake River floodplain for irrigation purposes. Production of livestock for meat and milk was also a major endeavor. Food processing plants were built along the banks of the Snake to allow easy disposal of wastes. The bustling agricultural industry along the floodplain of the Snake ceased to exist when Lower Granite Dam was completed in 1975 (Kamimura and Froyalde 2000a, Petersen 2001).

<u>Garfield County</u>
A Nez Perce Indian named Daniel Types is believed to have been the first permanent settler in Garfield County. Types, a convert of Henry Spalding grew corn and other vegetables in the Alpowa Valley. The first white settler, Parson Quinn arrived in the Pataha Valley. Immigrants began to stream into Garfield County once a stagecoach line was established between Walla Walla and Lewiston in 1862. In 1864, J.M. Pomeroy built an eatery and stage shop in what would later become the town of Pomeroy. Cattle ranching and vegetable farming dominated agricultural production in the early years, because wheat farming was not yet recognized as a

profitable venture. Asotin and Garfield Counties were originally part of Columbia County. In 1877, Columbia Center became the first town platted in the future Garfield County. The town initially prospered with sawmills, flourmills, a post office, stores, saloons, restaurants, stables, blacksmiths, a school, and homes, but faded away in the 1880s when it was bypassed by the Union Pacific railroad line between Starbuck and Pomeroy. The town of Pomeroy was platted in 1878. Garfield County was incorporated in 1881. The county was named in memory of President James A. Garfield who had been assassinated earlier that year. The Starbuck to Pomeroy rail line was crucial to commerce in the region. Grain production increased substantially near the turn of the century. In 1942, Blue Mountain Cannery began operation in Garfield County. The plant packed peas for the Green Giant label. Substantial pea harvests occurred in the 1950s, but a doubling of freight made the plant unprofitable. It closed in 1960. The pea plant was purchased by the Robert Dye Seed Ranch, which packaged bluegrass seed for the O.M. Scott Lawn Seed Company. The company was the largest bluegrass seed producer in the nation by 1963. Completion of the lower Snake River Dams in the 1970s improved transportation in the county. By 1981, the Union Pacific rail line between Starbuck and Pomeroy was abandoned because of several years of losses (Kamimura and Froyalde 2000b).

Columbia County

This county was named in honor of the Columbia River. It was incorporated in 1875 from Walla Walla County and initially included Garfield and Asotin Counties to the East. Most early residents of Columbia County arrived in the 1860s and settled in the Touchet River Valley. Livestock production was the main economic venture. By the 1870s, 3,000 to 4,000 head of cattle and 10,000 head of sheep were grazing in the county. By the early 1900s, production had largely switched to farming. The river bottoms were the first areas cultivated, but it was quickly discovered that the neighboring hillslopes were also fertile. Farmers in the county organized in 1922 by creating the Columbia County Farm Bureau. The Columbia County Grain Growers and Columbia County Grange soon followed. Logging in the Blue Mountains was a major industry in the county. Crude sawmills provided lumber for the county's first homes. Logging continued to grow from the 1880s to the early 1900s. Logs were pulled from the forest with teams of oxen and greased skids or floated down rivers. The Blue Mountain Cannery was constructed in Dayton in 1934. It was one of the nation's largest and most modern packing plants at the time. During the first year the company canned about 7,500 cases of peas per day. Asparagus production became important a few years later. The plant changed hands several times and is now owned by the Seneca Corporation, a major employer in Columbia County. Grain production is the county's other top industry (Barrier 1997).

Whitman County

The first white settlers arrived in 1868 and Whitman County was incorporated in 1871. Livestock grazing was the primary activity in the early years. The abundant grasslands fed thousands of head of cattle, sheep, and horses. By the early 1870s, settlers began converting grasslands to agricultural production of wheat, oats, barley, flax straw, apples, peaches, plums, currants, gooseberries, raspberries, and peas. The fruit crops were grown primarily along the banks of the Snake River. Wheat was the dominant crop in the uplands. Steamboats and stagecoaches were the primary transportation during the 1860s and 1870s. Railroads arrived in the 1880s. The State Agricultural College of Washington (now Washington State University, WSU) was founded in Pullman in 1890. Agriculture remains king in Whitman County to this day (Barrier and Froyalde 1999)

Livestock Production

The Nez Perce grazed horses along the Snake River as early as 1730 (Northwest Power Planning Council 2001d). European settlers arrived in the area in the 1860s and began grazing sheep and cattle in the Blue Mountains. Sheep were grazed above timberline while cattle generally grazed below timberline. Sheep could get by with obtaining moisture from forage, but cattle needed drinking water. Therefore, the cattlemen took the river bottoms while the sheepmen grazed the high ridge tops (Johnson 1995). Huge herds of sheep and cattle were raised in southeast Washington and exported to mining districts throughout the Columbia Basin until about 1865 when the gold rush essentially ended (Meinig 1968). In 1906, 150 head of horses, 900 head of cattle, and 15,000 head of sheep were grazing the upper Tucannon watershed. A "head" counts only animals greater than 6 months of age (Johnson 1995). Around the same time, 30,000 sheep (assumed to count all animals) were grazing the Asotin Creek headwaters (Asotin County Conservation District 1995). Ranching alternated between cattle and sheep based on climatic conditions and market demands. In 1915 cattle farming dominated, but wool and meat were needed to supply soldiers in World War I and World War II, so sheep production increased (Northwest Power Planning Council 2001d). In 1905, cattle grazing on USFS lands along the Tucannon was confined to between May 15 and October 31 (Johnson 1995).

The original rangeland plant community was dominated by bluebunch wheatgrass and Idaho fescue along with a variety of forbs. Poor range management led to deteriorated rangeland condition throughout southeast Washington (Asotin County Conservation District 1995, Johnson 1995, Columbia Conservation District 1997, Pomeroy Conservation District 1998, Northwest Power Planning Council 2001d). Sheep were particularly hard on rangeland because of their close-crop grazing habit and continual grazing of already depleted pastures. The 1930s were particularly damaging because sheep growers were struggling to stay in business by grazing damaged rangeland. The last sheep operation in the Tucannon closed down in the 1940s. Heavy grazing severely damaged rangelands (Johnson 1995).

The following two paragraphs were contributed by Del Groat, USFS Pomeroy Ranger District: The Upper Tucannon area served as a base encampment for cattle and sheep runs into the upper reaches of the Tucannon River, and later onto state and federal reserve lands as early as the 1860's. Grazing has been a part of the Blue Mountains since that time. Sheep and cattle began to graze in what later became the Umatilla National Forest in 1875 (Tucker 1940). The use of the forest area for summer grazing increased from year to year, especially with regards to the number of sheep. In 1905 records show that 9,000 ewes were grazed by R.A. Jackson on land that included the Tucannon River, Oregon Butte, Little Tucannon River, McBain Spring, Panjab and Turkey Tail (Tucker 1940). Contemporary newspaper reports reveal a healthy ranching business, particularly in sheep. A map of the then Wenaha National Forest dated 1908 (CRMF Pomeroy Ranger District) shows extensive cattle ranges and nine sheep ranges on forest land within easy travel of the Upper Tucannon settlement. Some local residents believe that erosion problems on the open hillsides, where there has been no logging or road construction, are the result of overgrazing by large sheep herds in the early grazing years. Cattle grazing in the mountains was confined to the outer edges of the timber and in the lower canyons along the fringes of the settlements in the Tucannon area.

The Pomeroy Allotment is the only grazing allotment located in the Tucannon Watershed Assessment area. Grazing management began on the present Pomeroy Allotment in 1967. The allotment was created by the merger of the old Tucannon Allotment (formed in 1939) the

Pomeroy Allotment (formed in 1949) and the Charley-Pataha Unit of the Peola-Pomeroy allotment (formed in 1939). The merger was made to improve deteriorated range conditions in the upper reaches of the Tucannon. The upper reaches of the Tucannon were vacated by the merger.

By the 1960s undesirable annuals such as cheatgrass, Japanese brome, and medusa-head ryegrass, and noxious weeds including yellow star thistle, musk thistle, and knapweed had taken root in the stands of native perennial bunchgrasses. The undesirable plants were highly resistant to chemical sprays and thoroughly overwhelmed the rangelands (Johnson 1995). Grazing on public lands went unregulated until 1939. In 1967 the upper Tucannon was closed to grazing, but the Panjab Creek allotments were grazed into the 1980s (Columbia Conservation District 1997). Minimal grazing was allowed in the Wenaha-Tucannon Wilderness Area until 1993 (Forest Service 1993b, unpublished work, Forest Service 1995a, unpublished work).

Agricultural Production

Dryland production of wheat rapidly expanded across the region in the 1870s. Wheat was grown at relatively little cost on the rolling loess covered hills, but as more land was brought into production the distance to shipping ports and cost of shipping grain increased. The Snake River was the principle transportation route for wheat grown in Asotin, Garfield, and Whitman Counties; unfortunately, the river is one thousand or more feet below the cropland in many cases. Growers originally drove wagons down tributary canyons to the river below, but it proved too dangerous and time consuming. As the saying goes, "Necessity is the mother of invention," so farmers constructed a wooden grain chute 3,200 feet long and 4-inches in diameter. Unfortunately, the original straight chute sent grain kernels hurling downslope so fast that they were ground to flour. After several runs of trial and error the system was perfected by adding bends and upturns (Meinig 1968). Although this system was an improvement over the white-knuckle wagon rides down canyons, it had plenty of room for improvement. Grain was hauled in bags, emptied into the chute, and then rebagged at the bottom of the canyon. This system proved labor intensive in addition to being prone to frequent clogs of the chute. A new system was developed using a cable and pulley system that reached from the canyon rim to the bottom (similar to a ski lift). Grain bags were attached to hooks on the cable and gravity sent them down to the bottom while forcing the empty hooks up to the canyon rim. This system was further improved by building rail lines that conveyed two freight bins propelled on a cable and pulley from the canyon rim to the valley floor below. As the loaded bin rolled down the track, the empty bin was pulled up the track. The tracks split in the middle of the slope so the two bins could pass each other (Petersen 2001). Getting the grain to the Snake River was not the only concern. Wheat was harvested from mid-August to mid-September, which coincided with low summer flows that halted navigation on the Snake from late September to March or April. If water levels prevented navigation, the crop would rot on the docks (Meinig 1968, Kamimura and Froyalde 2000b). Although dryland farming in the uplands was the dominant agricultural producer, river bottoms were used for production of irrigated alfalfa hay, small grains, orchards, and vegetables (USDA Soil Conservation Service *et al.* 1981a, Asotin County Conservation District 1995, Johnson 1995).

Timber Production

Settlers began harvesting timber in the upper Tucannon in the late 1800s. The logs provided building materials, fencing, and fuel for the growing population in southeast Washington. By 1905, the best saw logs had already been harvested. The majority of commercial logging in the Tucannon watershed has occurred since the 1950s. Early timber harvest focused on selective harvest of only the most valuable mature trees (Johnson 1995). Skid trails were reseeded following harvest, but reseeding produced poor results, so managers began replanting with seedlings. By the 1960s, clearcutting was the logging method of choice. In 1965, the Forest Service sold 10.5 million board feet of timber in the Meadow Creek watershed. Logging also took place on the Little Tucannon adjacent to the Meadow Creek sale. Units were also sold at Ruchert Springs, Turkey Creek, Grub Canyon, Huckleberry Butte, Mt. Misery, and the slopes along the right bank of the Tucannon from Sheep Creek downstream. A boom in U.S. housing and the associated demand for lumber led to the Forest Service motto: "getting the cut out (Johnson 1995)." Logging also occurred on both public and private lands within the Grande Ronde, Asotin, and Alpowa-Deadman Subbasins (Northwest Power Planning Council 2001a, Northwest Power Planning Council 2001c).

The following two paragraphs were contributed by Del Groat, USFS Pomeroy Ranger District:
Timber harvest in the Northern Blue Mountains began with the first mill built about one mile above Columbia Center in 1874 by Henry Sharpnack (Tucker 1940). Numerous mills, located along the foothills of the Forest, were erected and moved as the new towns began to spring up in southeast Washington. The demand was so high and so much material was removed from the Forest it was remarked by an unnamed individual “there wasn’t a tree left on Stevens Ridge.” Forest protection laws resulted in the Wenaha Reserve May 12th 1905, permanently removing the lands from “Homestead Entry.” The harvest activity that we are all familiar with today really began in 1956. Post-war demands for timber on booming housing starts with modern harvest equipment and the Country’s need for roads to support recreation and expansion.

On the Pomeroy Ranger District, which manages National Forest Lands, there have been about 75,000 acres cut for sale. This number is deceiving, because most of the harvest activity has covered the same ground repeatedly due to the differences in management techniques. An estimated one half to two thirds of the harvested acres were treated as many three times (Walker 2000, personal communication). First entry of a unit might be a partial cut, followed by a shelterwood, followed by overstory removal. Harvest acres would be counted each time. Timber removed from a clear-cut in1960 thirty years later in 1990 might be commercially thinned. These acres would have been totaled into the number of acres harvested. Only about 56,000 suitable acres of the nearly 160,000 acres of managed National Forest lands, outside the wilderness, are available for harvest. This excludes areas such as riparian, wetlands, open meadows, viewsheds and roadless areas. Designated riparian buffers known as RHCA’s (Riparian Habitat Conservation Areas) may be a minimum of three hundred feet in fish bearing habitat. This strategy further reduced the available, suitable harvest acres by an estimated 25% reducing that number to 42,000 acres.

A system was needed to get grain and wood to downstream markets and fuel and other products upstream. From 1876 to the early 1900s most wheat was transported down the Snake River by a fleet of 16 steamboats referred to as the “wheat fleet.” Though the fleet initially prospered, difficult navigation conditions during the dry season, and the expansion of railroads throughout southeast Washington threatened its continued existence. Railroads initially shipped at cut rates in an attempt to gain control of the freight market (Petersen 2001). By the early 1900s, railroads held a virtual monopoly on freight in southeast Washington (Kamimura and Froyalde 2000b) and the wheat fleet was no more (Petersen 2001). In the 1930s, it cost 50 cents per ton to barge freight 1,000 miles from Duluth, Minnesota to Buffalo, New York. Freight was towed 550 miles by boat from Kansas City to Chicago for $1.94 per ton. During the same time period railroads in the inland Northwest charged $4.80 per ton to ship wheat less than 400 miles to ports in Portland or Seattle (Petersen 2001). Seeking to break the railroad monopoly (Kamimura and Froyalde 2000b) and improve upon what nature had provided, plans were developed to construct a series of locks and dams from the Cascades of the Columbia (site of Bonneville Dam) to Lewiston, Idaho (Dietrich 1997, Petersen 2001).

Lower Snake River Dams

Efforts to build the four dams on the lower Snake River began to gain strength in 1934 with the creation of the Inland Empire Waterways Association. A Walla Walla salesman named Herbert G. West was appointed representative of the organization. He lobbied vigorously for a system of dams and locks from Bonneville to Lewiston. Federal funding for the project repeatedly stalled in Congress until 1955 when Washington Senator Warren Magneson quietly inserted a $1 million appropriation into a bill to begin construction of Ice Harbor Dam. From then on, the U.S. Army Corps of Engineers requested additional funding to complete the chain of dams. Support for the dams was not universal. The Washington Department of Fish and Game objected so strongly that they suggested 387 alternative sites that would produce hydroelectric power with less biological damage (Dietrich 1997, Petersen 2001). Ice Harbor Dam was completed at RM 10 in 1961, forming Lake Sacajawea. Lower Monumental Dam followed at RM 42 in 1969, impounding Lake Herbert G. West. Little Goose Dam was completed in 1970 at RM 70, forming Lake Bryan. Lower Granite Dam at RM 107 was the final dam completed in 1975, creating Lower Granite Lake. Fish ladders for adult salmonid passage were included in the original design of each dam, but the requirements of juvenile salmonid passage were not well understood until about 1997 (Army Corps of Engineers 1999). Following completion of Lower Granite Dam, the U.S. Army Corps of Engineers made Herbert G. West the second recipient of the Corps' Civilian Service Medal. He was later elected mayor of Walla Walla (Dietrich 1997, Petersen 2001). In 1978 the reservoir behind Lower Monumental Dam was named for him (Army Corps of Engineers 1999). During a dam completion ceremony at Lewiston in 1975, Idaho Governor Cecil Andrus warned that the lower Snake River dams would doom Idaho's salmon runs. "I want to point out that the cost of this system has been horrendous, both in dollars and in cost to our natural resources (Dietrich 1997, pg. 206)." Completion of the Lower Snake River dams made Lewiston, Idaho the furthest inland (460 miles) seaport on the west coast of the United States (Kamimura and Froyalde 2000a, Petersen 2001). In October 1976 the Lower Snake River Fish and Wildlife Compensation Plan (LSRCP) was signed into law. The act originally included an appropriation of $58.4 million (later significantly enlarged) to acquire 24,150 acres of wildlife habitat, fishing and hunting access, and construction of nine fish hatcheries. At the time the LSRCP was the most expensive mitigation effort undertaken in U.S. history (Petersen 2001).

Flood history

Devastating floods caused substantial damage to riverine habitat and private property in December 1964, January 1965, 1974, December 1996, and January 1997. The floods of 1964 and 1965 coupled with channel and floodplain modifications prior to and following the floods removed the majority of mature trees in the riparian zones of the mid-to lower reaches of the Tucannon River (Esmaili and Associates 1982) and Asotin Creek (Asotin County Conservation District 1995). Flows reached 7,980 cfs (at the USGS Starbuck gage) during the 1964 flood on the Tucannon and 3,700 cfs (at the Kearney Gulch gage) during the 1974 flood on Asotin Creek (Esmaili and Associates 1982). Bank armoring and dikes were installed to protect property and roads. The removal of riparian vegetation coupled with channel straightening and hardening led to shorter and steeper channels conveying increased energy. From 1937 to 1978 Tucannon River channel length was decreased from 7 to 20% depending upon stream reach, and sinuosity decreased by 50% (Esmaili and Associates 1982). Similar activities occurred on Asotin Creek resulting in the same types of damage. The increased energy resulted in erosion of unstable banks and led to many reaches dominated by braided channels (for a few years subsequent to the floods) on Asotin Creek (Asotin County Conservation District 1995) and the Tucannon River (Esmaili and Associates 1982). Trees had recolonized the riparian zone of Asotin Creek following the 1974 flood, but the channel was too wide to allow effective shading (Asotin County Conservation District 1995). Trees also recolonized the riparian zone of the Tucannon River, but the quality of the buffer was far below the historic buffer (Columbia Conservation District 1997). Unfortunately, December 1996 and January 1997 brought catastrophic floods that destroyed much of the young riparian vegetation along both Asotin Creek and the Tucannon River (Columbia Conservation District 1997, Northwest Power Planning Council 2001a). As an example, canopy cover along the upper 14 miles of mainstem Asotin Creek ranged from 60 to 80% during 1993 surveys, but had been reduced to 20 to 40% when assessed in 2000 (Natural Resources Conservation Service (USDA) 2001). However, flood damage was not universal, in some headwater reaches conditions such as substrate embeddedness and LWD abundance actually improved (TAG 2001, personal communication).

WATERSHED DESCRIPTION

Location

The Lower Snake Watershed, Water Resource Inventory Area (WRIA 33) begins at the confluence of the Palouse and Snake Rivers and continues downstream to the mouth of the Snake at the Columbia River. All tributary streams that flow into this reach of the Snake River are included in this basin (See Map 1). The basin drains approximately 722 square miles and encompasses portions of Columbia, Franklin, and Walla Walla Counties.

The lower six miles of the Palouse River (WRIA 34) are evaluated in this report. The remainder of WRIA 34 will not be evaluated because 185-feet high Palouse Falls blocks anadromous fish runs and bull trout are not present in the headwaters of the Palouse River within Washington. The Palouse Watershed drains portions of Whitman, Spokane, Adams, and Franklin Counties, as well as portions of northern Idaho.

The Middle Snake Watershed (WRIA 35) is located in the extreme southeast corner of Washington. The WRIA is bordered by the state of Oregon to the south, the state of Idaho to the east, the Palouse Watershed (WRIA 34) to the north, and the Walla Walla (WRIA 32) and Lower Snake (WRIA 33) Watersheds to the west (See Map 2). The basin drains approximately 2,250 square miles within the state of Washington. This includes about 340 square miles of the lower Grande Ronde Watershed (about 4,100 square miles total). The Clearwater Watershed of Idaho (approximately 9,350 square miles) enters the Snake River at the Cities of Lewiston, Idaho and Clarkston, Washington (Washington State Conservation Commission and Northwest Indian Fisheries Commission 2001, unpublished work). The Oregon portion of the Grande Ronde Watershed and the Clearwater Watershed will not be assessed in this report. The Middle Snake Watershed encompasses portions of Asotin, Whitman, Garfield, and Columbia Counties within Washington. Diamond Peak located in the headwaters of the Tucannon River is the highest point in the basin with an elevation of 6,380 feet (DeLorme Mapping 1995), while the mouth of the Palouse River is the lowest point at about 540 feet (Army Corps of Engineers 2000).

Population and Ownership

WRIA 33

No towns or cities are located in this watershed. The entire watershed is privately owned with the exception of small parcels along the Snake River reservoirs owned and maintained by the U.S. Army Corps of Engineers, the McNary National Wildlife Refuge owned and maintained by the U.S. Fish and Wildlife Service, and the Juniper Dunes Wilderness Area (Washington Department of Natural Resources 2001) (See Map 3).

WRIA 34

No residences are located in the Palouse River canyon downstream from Palouse Falls (TAG 2001, personal communication). Land ownership was not investigated for this very small area.

WRIA 35

Year 2000 U.S. Census Bureau information was used to estimate the population in the Middle Snake Watershed. The total population of Asotin County was 20,551 (19,256 of which lived in the cities of Asotin or Clarkston and surrounding areas). No major population centers are present in the Whitman County portion of the WRIA. The city of Pomeroy was the most populated area in Garfield County with 1,517 residents. The largest town in the Columbia County portion of the WRIA was Starbuck with a year 2000 population of 130 (Census Bureau 2001a, Census Bureau 2001b). Private land comprises 1,711 square miles (76%) of the WRIA. The federal government owns 436 square miles (19%) of the basin, while the state of Washington owns 103 square miles (about 5%) (Washington Department of Natural Resources 2001) (See Map 4).

Geology

The geologic history of southeast Washington began about 110 million years ago when a group of 250 million year old volcanic islands and sea floor from the Pacific Ocean rode up onto the western edge of the North American continent, forming the Blue and Wallowa Mountains. Stretching of the Earth's crust along this seam released vast quantities of molten rock that flowed up through fissures in the ground. The lava flows covered the area referred to as the Columbia Plateau with numerous layers of basaltic rock thousands of feet thick. The ancient sea floor and lower slopes of the volcanic islands are now buried beneath the basalt. The most significant lava flows, commonly referred to as the Grande Ronde basalts, occurred between 16.5 and 14.5 million years ago. This rock represents about 85% of the total volume of the Columbia Plateau basalts. The Blue and Wallowa Mountains originally had an approximately north-south orientation straddling the Washington-Idaho border when an immense chamber of granitic magma called the Idaho Batholith caused uplift of the mountain ranges. The overlying basalts were tilted upward yielding a slope trending downward from the east to the west. A 60-degree clockwise rotation of the mountain ranges produced the orientation and general southeast to northwest slope of the present day Blue Mountains. Folding and faulting coupled with stream erosion have also played a major role in formation of the topography seen today (Alt and Hyndman 1995, Alt and Hyndman 1998).

The Columbia River Basalt flood flows were separated by long stretches of erosion and deposition of porous material. The porous material was sandwiched between the basalt flows. The climate of "Washington" was very wet during the time of the basalt flows, but it was very dry during most of the last 35 to 40 million years. The dry climate and outwash from receding ice age glaciers created vast quantities of fine-grained sediment that was deposited in north central Oregon and south central Washington. This sediment was carried by the prevailing southwest winds and deposited on top of the basalts, forming the huge dunes commonly referred to as the "Palouse." Today these highly erodible loess soils are some of the most fertile cropland in the world (Alt and Hyndman 1995, Alt and Hyndman 1998).

The immense Spokane Floods dramatically altered the topography of the Columbia Plateau. The floods occurred as many as 100 times (about 16,000 years ago) when an ice dam blocked Idaho's Clark Fork River, forming Glacial Lake Missoula. This lake was about 2,000 feet deep and held an estimated 500 cubic-miles of water. Eventually the water level rose high enough to float and break the ice dam, sending a wall of water over one-third mile high rushing over eastern Washington. The floods are estimated to have traveled at 45 miles per hour with a flow of nine cubic-miles per hour — more water than the combined flow of all the present day rivers of the world. The flows created the channeled scablands of the region just north of the Snake River. The floods did not pass through the Snake River Valley, but they did back up flow of the Snake and other tributaries. At one time, the impounded water of the Snake River was estimated to be 600 feet deep in the Lewiston/Clarkston area. Although not nearly as grand in magnitude as the Spokane Floods, the Bonneville Flood created the deep canyon that the Snake River flows through today. Lake Bonneville was located in the basin of the Great Salt Lake in Utah during the last ice age. The lake eventually overflowed through Red Rock Pass near Pocatello, Idaho. The outflow carved a channel 375 feet deep through the top of the pass until the incision was stopped by hard rock (Alt and Hyndman 1995, Alt and Hyndman 1998).

Hydrology

McNary Dam (RM 292 on the Columbia River), Ice Harbor Dam (RM 10), and Lower Monumental Dam (RM 42) impound the Snake River in WRIA 33, while Little Goose Dam (RM 70) and Lower Granite Dam (RM 107) impound the Snake River in WRIA 35. The backwater from Lower Granite Dam extends upstream to the City of Asotin (RM 146). The Snake River is free flowing from this point upstream to Hells Canyon Dam (RM 247) located upstream from the upper end of WRIA 35. Groundwater flows through cracks in the basalt layers as well as the porous sediments sandwiched between the basalts (Alt and Hyndman 1998). Fractured zones and sedimentary interbeds in the Columbia River Basalts carry considerable quantities of groundwater that supply water for irrigation and municipal use. Springs provide substantial flow to streams in areas where the channel has cut into a fractured layer of basalt (Covert *et al.* 1995).

Vegetation

WRIA 33, 34

Historically the Lower Snake Watershed was covered by prairie and canyon grasslands and shrub-steppe vegetation (See Map 5). Today much of this native vegetation has been converted to crop and livestock production. Non-irrigated row crops, primarily wheat, are the dominant vegetative cover comprising about 34.5% of the acreage in the watershed. Grass-forb vegetation disturbed by logging, burning, or heavy grazing covers about 21% of the watershed. Irrigated crops are grown on about 17% of the watershed. The remainder of the watershed is covered by a variety of vegetation classes (Washington Department of Fish and Wildlife 1996) (See Map 7).

WRIA 35

Historically the Middle Snake Watershed was covered with prairie and canyon grasslands and shrub-steppe at low to mid-elevations. Forests dominated as elevation and proximity to the Blue Mountains increased (See Map 6). Today much of the prairie grasslands and shrub-steppe vegetation have been converted to crop and livestock production. Non-irrigated row crops, primarily wheat, and grass-forb plant communities comprise roughly 37% and 30% of vegetative cover in the watershed respectively. Coniferous forests cover about 20% of the watershed, while shrubs and trees are present on about 7%. The remaining 6% of the watershed is covered by a multitude of various vegetation classes (Washington Department of Fish and Wildlife 1996) (See Map 8). Harvest of large disease and fire resistant trees, fire suppression, heavy grazing, and introduction of blister rust have changed mountain timber communities from mixed age stands dominated by pines with an open understory to homogenous mid-seral stands dominated by thick stands of firs. These forests have accumulated large fuel loads and are highly susceptible to catastrophic crown fires (Forest Service and Bureau of Land Management 1996). Prior to Euro-American settlement periodic fires maintained an open park-like community of large shade-intolerant trees that were resistant to stress, fire, insects, and disease. Historically the mid-seral communities either burned and reverted to early-seral plant communities or they matured to late-seral communities. Western white pine, whitebark pine, ponderosa pine, western larch, aspen, cottonwood, riparian willows, bitterbrush, mountain mahogany, and bluebunch wheatgrass were historically the dominant trees, shrubs, and grasses in the Interior Columbia Basin (Forest Service and Bureau of Land Management 1996).

The following two paragraphs were contributed by Del Groat, USFS Pomeroy Ranger District: Equivalent Clearcut Acre model (ECA) is a management tool for calculating watershed condition. This is the accepted tool by National Marine Fisheries Service and U.S. Fish and Wildlife Service. The model uses roads, harvested acres and a recovery time to predict the number of acres within a watershed in less than a thirty-year age class. Thirty percent was the accepted value of the acres within a watershed in the less than thirty year age class (McCammon 1993). This was the threshold where a watershed could sustain and hold back stream flows to prevent erosion and habitat degradation. This value was reduced by PACFISH (Implementation of Interim Strategies for Managing Anadromous Fish Producing Watersheds) standards to twenty percent. NMFS further reduced the number to fifteen percent during initial chinook salmon consultations. The current ECA conditions for the Northern Blue Mountain watersheds are as follows: Asotin 10%, with the highest ECA sub-watershed in Charley Creek at 20%; Tucannon 5.1% with Cummins, Meadow and Little Tucannon sub-watersheds each approaching 10%. Private acreage outside Federal lands was not considered in the calculations.

Forest Service land management has taken a new direction as ESA listed species came to the forefront. No longer are clearcuts being allowed as a management tool. RHCA's, wetlands and roadless areas are currently excluded from harvest planning. Harvest activity "purpose and needs" are restricted to forest health condition and values. The agency is trying to restore the Historic Range of Variability's (HRV's) back to pre-settlement conditions. Only undesirable tree species and over stocked desired species may be removed from the landscape. Understory trees that are exceeding recommended stocking levels may be taken. Reducing stocking levels and ladder fuels can minimize the risk of unhealthy stand conditions and catastrophic fire, which could have negative effects on soil and water resources as well as wilderness, state and private lands. Select harvest and prescribed fire will be the dominant tools to meet this objective.

Land Use and Salmonid Habitat Conditions

WRIA 33, 34

The Lower Snake Basin is arid. This area falls in the rain shadow of the Cascade Mountains to the west. Average annual precipitation is five to 10 inches (Daly and Taylor 1998) (See Map 9). Lands in close proximity to the Snake River are predominantly used for irrigated agricultural production of apples, grapes, alfalfa, hybrid cottonwood, potatoes, peas, and wheat. The majority of lands away from the Snake River are dry farmed or used for rangeland (Kuttel 2001b). The lower six miles of the Palouse River flow through a deep canyon carved out by the Spokane Floods discussed earlier. No farming, grazing, or settlements are located in the valley of the Palouse River below Palouse Falls. Grass-forb vegetation disturbed by logging, burning, or grazing is the primary land cover on the ridges adjacent to the Palouse River Canyon (Washington Department of Fish and Wildlife 1996) (See Map 7).

WRIA 35

The Middle Snake Basin is semi-arid. Average annual precipitation ranges from five to 10 inches in the low lands along the Snake River up to 45 inches in the peaks of the Blue Mountains (Daly and Taylor 1998) (See Map 10). About 90,390 acres (43%) of the Asotin Creek Watershed are used as pasture and rangeland. Livestock are wintered in canyon bottoms from December through March. Following calving most cattle graze the lower canyon slopes until June or July when they are moved to forested pastures. Crop aftermath and canyon slopes are grazed in the fall and early winter (Northwest Power Planning Council 2001a). As of 1993, about 70% of stream banks on private lands were fenced to prevent livestock access to the stream (Asotin County Conservation District 1995). Overgrazing is still a problem on some reaches, particularly portions of Charley Creek and George Creek. Cropland occupies about 54,960 acres (26%) of the Asotin Creek Watershed. Winter wheat and spring barley with summerfallow every two to three years are the dominant crops. About 30% of the cropland is currently enrolled in the Conservation Reserve Program (CRP) (Northwest Power Planning Council 2001a). Forests cover about 62,620 acres (30%) of the Asotin Creek Watershed. The majority of timberlands are found within the Umatilla National Forest. The state of Washington and non-industrial private forestland owners manage the remaining forests (Northwest Power Planning Council 2001a).

Grazing is practiced on about 120,650 acres (37%) of the Tucannon Watershed. Grazing generally occurs on ground either too steep, rocky, or dry to farm (Northwest Power Planning Council 2001e). Winter wheat, barley, peas, and bluegrass seed are grown on about 116,000 acres (36%) of the Tucannon Watershed; while alfalfa, small grains, and pasture are produced on about 3,000 acres (1%) of irrigated bottomlands (USDA Soil Conservation Service *et al.* 1984). The Forest Service manages about 56,385 acres (18%) of forestland within the Tucannon Watershed. The state of Washington manages about 4,950 acres (1.5%) of timber (does not include the approximately 15,000 acre Wooten Wildlife Area (4%), while non-industrial private forestland owners and corporate landowners manage about 6,830 acres (2.5%) (Northwest Power Planning Council 2001e). Public lands in the Tucannon Watershed are used heavily for recreational purposes (TAG 2001, personal communication, Northwest Power Planning Council 2001e).

As of 1981, 86,000 acres (66%) of the Deadman Creek Watershed (includes Meadow Creek) were being used for dryland crop production. About 37,700 of these acres (44% of cropland) were fallow. Rangeland accounted for 43,000 acres (33%) in the Deadman Creek Watershed. About 27,000 acres (33%) of the Alpowa Creek Watershed were also dry cropped with about 11,400 acres (42% of cropland) fallow. About 51,000 acres (61%) were grazed in the Alpowa creek Watershed. Along the Snake River, about 310,000 acres (35%) were in dry crop production with 140,800 acres (45% of cropland) fallow. About 82,000 acres (9%) of irrigated farming were also present along the Snake River. Livestock was raised on about 422,000 acres (47%) along the Snake. Deadman Creek had no forestland, while Alpowa Creek and the Snake River had 4,000 acres (5%) and 3,000 acres (0.3%) respectively (presumed to be riparian vegetation) (USDA Soil Conservation Service *et al.* 1984).

Conversion of perennial bunchgrass prairies to production of annual crops has led to widespread and massive quantities of fine sediment erosion and deposition in WRIA 35 streams (USDA Soil Conservation Service *et al.* 1984, Asotin County Conservation District 1995, Columbia Conservation District 1997). George Creek (Asotin Subbasin), Deadman and Meadow Creeks (Alpowa-Deadman Subbasin), and Pataha Creek (Tucannon Subbasin) are the most significant producers of fine sediment. The majority of fine sediment deposition in the Tucannon and Asotin Subbasins occurs in the lower ends of receiving streams on private lands where other habitat features including riparian buffers, channel morphology, floodplain function, and instream structure have been moderately or severely degraded (Esmaili and Associates 1982, Asotin County Conservation District 1995). Runoff rates are thought to have increased with the reduction in vegetative cover and soil compaction associated with tillage and grazing. Increased runoff led to increased flood magnitude during heavy precipitation and rain-on-snow events

(Esmaili and Associates 1982). No-till/direct seed farming is being employed on additional acreage each year throughout southeast Washington. This method of farming reduces soil erosion and improves infiltration of precipitation into the soil. Pomeroy Conservation District and Washington State University are currently conducting a study to determine the significance of infiltration improvement attained through no-till/direct seed farming (TAG 2001, personal communication).

Floodplains throughout WRIA 35 have been converted to agricultural and residential use. The valley bottoms were particularly attractive for use as irrigated farmland. Large amounts of riparian forests were cleared to increase cropland and pasture acreage. Residents grew tired of flooding and took actions to protect their property. These actions included straightening stream channels, removing instream large woody debris, armoring banks, and diking floodplains (Esmaili and Associates 1982, Asotin County Conservation District 1995, Columbia Conservation District 1997). Unfortunately, these actions set in motion a chain of events that only worsened the destructive power of floods by increasing stream energy. Floodplains, instream structure, riparian vegetation, and sinuous stream channels enable a stream to dissipate energy. Disrupting these natural functions forced streams to erode banks to release energy. The streams' ability to transport sediment was also reduced resulting in the formation of mid-channel gravel bars that exacerbated bank erosion by forcing flow toward the banks. These problems were particularly acute on the Tucannon River where the stream's length was reduced from seven to 20% and sinuosity reduced by 50% from 1937 to 1978. Altering the system led to continual maintenance followed by more extensive flood damages, followed by more maintenance (Esmaili and Associates 1982, Columbia Conservation District 1997).

Irrigated agriculture in the valley bottoms was also destructive to juvenile salmonids. Unscreened diversions were commonly in use on both Asotin Creek and to a larger extent on the Tucannon River from the late 1800s to the early 1900s (McIntosh *et al.* 1989b). Salmon were not a priority in southeast Washington when compared to agricultural production. Attempts were made to screen diversions from 1939 to 1990, but floods and problems with maintenance either damaged screens or made them ineffective. From 1860 to 1960, at least 90 years passed with unscreened diversion ditches along the Tucannon River. As of 1980, only four gravity diversions remained on the Tucannon. The majority of producers now use pumps and sprinkler systems. State-of-the-art fish screens were installed on the Tucannon diversions from 1990 to 1992 (Johnson 1995). As of 1994 all the diversions along Asotin Creek had either been shut down or screened (Asotin County Conservation District 1995). Irrigation lowered stream flows on the Tucannon River and contributed to increased summer water temperatures (Johnson 1995). However, flow quantities have not been reduced to the extent of those found in the neighboring Walla Walla Watershed where large-scale irrigated agriculture has led to severe water quantity problems (Kuttel 2001a).

Today the best remaining salmonid habitat is found on state and federal lands in the headwater areas of WRIA 35 streams. Unfortunately, these are small streams with naturally high gradients and often-limited quantities of pool habitat and spawning gravels. Land use impacts on private lands along downstream reaches have had profound negative effects on salmonid habitat (See Map 8).

SALMONID STOCK STATUS

Spring/Summer Chinook

The Snake River Basin historically produced a substantial portion of Columbia River spring chinook, likely as many as 1.5 million fish (National Marine Fisheries Service 2000). Abundance was reduced substantially by the mid-1900s with an estimated return of 125,000 fish each year from 1950 to 1960 (Fulton 1968, cited in Northwest Power Planning Council 2001d). Returns continued to decline from 1977 to 2000. Returns increased dramatically in 2001, likely the result of favorable conditions during smolt outmigration and improved ocean conditions (Fish Passage Center 2001a, Fish Passage Center 2001b, Fish Passage Center 2001c) (See Figure 2 and Figure 3). Spring/summer chinook *(Oncorhynchus tshawytscha)* were historically distributed throughout the Middle Snake Watershed with the majority of spawning and rearing taking place in the Grande Ronde River, Wenaha River, Asotin Creek, and the Tucannon River. Anecdotal accounts also describe a run of spring chinook in Joseph Creek (Parkhurst 1950, Fishery Steering Committee 1957, Van Cleve and Ting 1960). The Tucannon River was a significant spring chinook producer. In 1915, an average of 500 adults per day entered the river in May and June. This equates to a run of 30,000 spring chinook! By 1935 the run had declined considerably to an average of 50 adults per day entering the river, or an estimated run of 3,000 fish (Parkhurst 1950).

Passage problems at the Starbuck Power Dam (RM 5.5) and Upper De Ruwe Dam (RM 16), naturally low spring and summer flows made worse by 31 surface water diversions, and juvenile mortality in unscreened diversions (28 of the 31 diversions identified were unscreened) all contributed to the decline in abundance (Parkhurst 1950, McIntosh *et al.* 1989b). Poaching was a significant factor in the decline as well. From the late 1800s to the 1950s, poaching of spring chinook on the Tucannon River was commonplace. Community leaders and landowners alike participated in the activity. One of the preferred tactics involved stringing chicken wire across the river and weighting down the bottom edge with a combine chain. Fish were gaffed, pitch forked, or speared when they were blocked by the chicken wire. Dynamite was used to poach salmon hiding in deep pools. The operators of the Starbuck Power Dam often diverted the entire flow of the Tucannon into the power plant, then returned flows through a tailrace. Returning spring chinook were naturally attracted to the flows of the dam tailrace. Operators would “shut down” the plant, stranding adult chinook in the dewatered tailrace so they could be poached. DeRuwe Dam was also a favored poaching site. The activity was so ingrained that some landowners posted signs on their property forbidding entry by game wardens, thereby protecting poachers from enforcement activities (McIntosh *et al.* 1989b, Johnson 1995).

Upper De Ruwe Dam was destroyed in the 1964 flood and a fish ladder was constructed at Starbuck Dam in 1992 (Northwest Power Planning Council 2001e). Only 54 adults returned to the Tucannon in 1995, the lowest return on record (Bumgarner *et al.* 2000, cited in Northwest Power Planning Council 2001e). The 2001 run produced a return of about 1,000 hatchery and wild spring chinook. Since 1980, WDFW has used LSRCP funds (and BPA funds since 1999) in an effort to restore Tucannon River spring chinook. The hatchery programs include a conventional smolt release program and a hatchery breeding program (Mendel 2002a, personal communication) (See Figure 1).

Asotin Creek was historically home to a run of spring chinook (Parkhurst 1950). The Washington Water Power Company Dam (WWPC Dam now known as Headgate Dam) located at RM 8.7 was a substantial barrier to adult spring chinook. Water was diverted for irrigation and drinking water for the cities of Clarkston and Asotin. The dam diverted the entire stream flow during low water periods, reducing the stream to a series of isolated pools below the dam. In 1934 the Washington Department of Game rescued 25 adult chinook and an estimated 250,000 juvenile steelhead that were stranded in these pools (McIntosh *et al.* 1989b). The WWPC Dam, unscreened surface water diversions and poaching all contributed to the decline of spring chinook in Asotin Creek. Redd counts since the early 1990s have been very low to nonexistent (Asotin County Conservation District 1995). The run is considered functionally extinct (Mendel 2002a, personal communication).

The Grande Ronde River historically produced a sizable run of spring chinook. These fish were more abundant than sockeye, coho, and steelhead. The main spawning area on the mainstem Grande Ronde was located above Sheep Creek and the East Fork Grande Ronde, high in the Oregon portion of the watershed (Fishery Steering Committee 1957). The Wenaha system also produced some chinook, but apparently produced far more coho (Parkhurst 1950, Fishery Steering Committee 1957, Van Cleve and Ting 1960). Snake River spring chinook were listed as threatened under the Endangered Species Act (ESA) on April 22, 1992 (National Marine Fisheries Service 1992). A petition to downgrade the status to endangered is pending (Northwest Power Planning Council 2001e). See Map 17 and Map 18 for the current spring chinook distribution. The lower Snake River (WRIA 33) is a migration corridor for spring chinook moving to and from tributary streams in WRIA 35 and the states of Oregon and Idaho. See Table 7 for spring chinook usage of individual stream reaches (See Figure 2 and Figure 3).

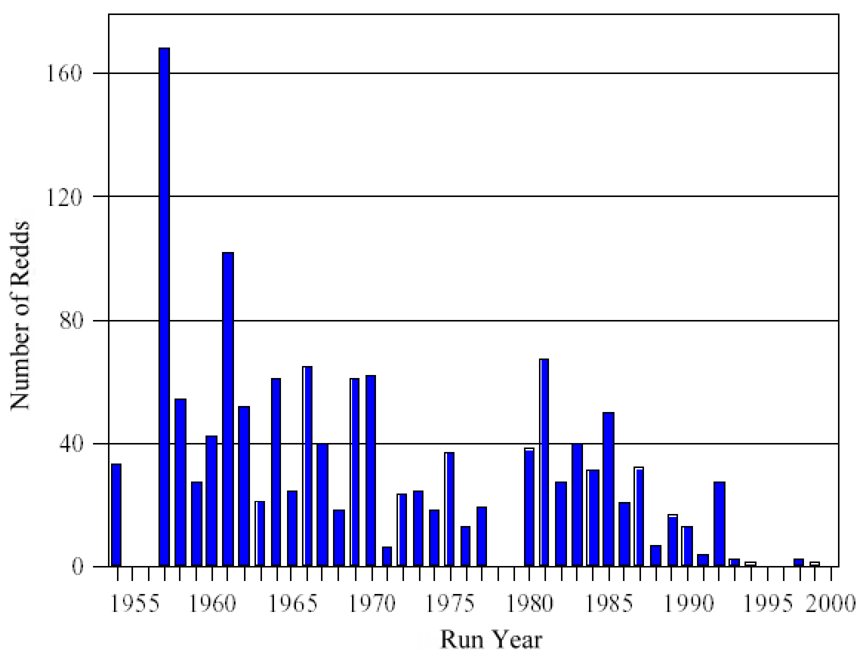

Figure 1. Tucannon River spring chinook redd counts (RM 42 to 45) 1955 to 2000. After Figure 18, (Northwest Power Planning Council 2001e). Data from WDFW Snake River Lab. Note that all adults were captured for broodstock in 1995 and 1996 because of extremely low returns.

Fall Chinook

Fall chinook *(O. tshawytscha)* were historically present as far upstream as Shoshone Falls (RM 615) on the Snake River (Gilbert and Evermann 1894, cited in Dauble 2000). Historic abundance of Snake River fall chinook is difficult to estimate, but adult returns appear to have declined by three orders of magnitude since the 1940s, and possibly by another order of magnitude when compared to pre-settlement levels (National Marine Fisheries Service 2000). From 1938 to 1949 the estimated annual mean return of fall chinook was 72,000, but the population declined to 29,000 by the 1950s (Irving and Bjornn 1981, cited in National Marine Fisheries Service 2000). From 1957 to 1960, 41,000 fall chinook returned to the Snake River. Adult counts over Lower Granite Dam numbered less than 1,000 fish annually from 1975 to 1992. Brownlee, Oxbow, and Hells Canyon Dams (completed in 1958, 1961, and 1967 respectively) blocked passage to spawning grounds in the upper watershed (Washington Department of Fisheries and Washington Department of Wildlife 1993). The average run size at Ice Harbor Dam through the 1990s was 5,500 fish. Returns improved substantially in 2000 and 2001 with 16,456 and 23,826 adults respectively counted at Ice Harbor (Mendel 2002a, personal communication). The best spawning grounds were located below Upper Salmon Falls (RM 578) (Evermann 1896, cited in Dauble 2000), but spawning also occurred from the confluence of the Clearwater River (RM 140) downstream to the mouth (Parkhurst 1950). The most important spawning areas in the lower river were found at the Palouse and Clearwater River confluences (Fulton 1968, cited in Dauble 2000). Dauble (2000) estimated that about 178 km (110.6 miles) of the free-flowing portions of the Snake River are suitable for spawning habitat. Unfortunately, 97% of this habitat is upstream from Hells Canyon Dam. No historic evidence shows extensive spawning in the Hells Canyon Reach prior to hydroelectric development (Dauble and Geist, in press, cited in Dauble 2000).

Today the majority of fall chinook spawning occurs downstream from Hells Canyon Dam (as far downstream as the town of Asotin) with some limited spawning in the tailraces of the four lower Snake River Dams (Washington Department of Fisheries and Washington Department of Wildlife 1993, Dauble 2000). Limited spawning occurs in the lower portions of the Grande Ronde, Tucannon, and Palouse Rivers (Washington Department of Fisheries and Washington Department of Wildlife 1993) as well as the tailraces of Lower Monumental and Ice Harbor Dams (Dauble 2000) (WRIA 33).

The Lyons Ferry egg-bank program was initiated in 1976 to save the Snake River fall chinook stock following completion of the four lower Snake River Dams. Adults were trapped at the Snake River dams, spawned at various hatcheries (until Lyons Ferry Hatchery was completed in 1985), then released into the Snake or Kalama Rivers. LSRCP was intended to mitigate for a cumulative loss of 48% of fall chinook smolts, plus a direct loss of 5,000 fish from lost spawning area. From 1959 to 1961, Snake River fall chinook returns were estimated at 32,660 fish. This escapement goal is currently met with a hatchery production target of 18,300 adults per year with the intent of providing in-place and in-kind mitigation as well as maintaining the genetic integrity of the run. Natural production makes up the balance of the escapement goal (14,360) (Mendel 1998, Mendel 2002a, personal communication).

The Snake River fall chinook population consists of wild fish, naturalized fish (offspring of hatchery fish that spawned in the wild), and hatchery fish. See Map 19 and Map 20 for the current fall chinook distribution. Snake River fall chinook were listed as threatened under the

ESA on April 22, 1992 (National Marine Fisheries Service 1992). See Table 7 for fall chinook usage of individual stream reaches (See Figure 2 and Figure 3).

Table 2. Fall chinook redd counts in the Snake, Tucannon, and Grande Ronde Rivers 1985 to 2000.

	Fall Chinook Redds		
Year	Tucannon River below Starbuck Dam	Grande Ronde River	Snake River Upstream of Lower Granite Dam
1985	0		
1986	0		7
1987	16		66
1988	26		64
1989	48		58
1990	61		37
1991	50		41[b]+5[c]
1992	21+2[a]	5	47
1993	21+7[a]	49	60[b]+67[c]
1994	25	15	53[b]+14[c]
1995	28+1[a]	18	41[b]+30[c]
1996	31+12[a]	20	71[b]+42[c]
1997	24+3[a]	55	49[b]+9[c]
1998	38+2[a]	24	135[b]+50[c]
1999	18+3[a]	13	273[b]+100[c]
2000	15+4[a]	8	255[b]+91[c]

Notes: (a) Redds found above Starbuck Dam. (b) Aerial count, the search area included the entire reach from Lower Granite Dam to Hells Canyon Dam. (c) Camera, the search areas were discrete sites composed mainly of 1 to 6-inch substrate. The number of sites searched varied each year. Tucannon data from (Milks et al. 2000, cited in Northwest Power Planning Council 2001e). Grande Ronde data from (Garcia 2001, unpublished work, cited in Northwest Power Planning Council 2001b). Snake River data from (Garcia 2001, unpublished work, cited in Northwest Power Planning Council 2001d).

Coho

Coho *(O. kisutch)* were historically present in the Wenaha, Grande Ronde and Tucannon Rivers (Parkhurst 1950, Fishery Steering Committee 1957, Van Cleve and Ting 1960). The Tucannon run was extirpated by 1929 (Parkhurst 1950), while the large run (Thompson and Haas 1960) in the Grande Ronde system was extinct by the 1980s (Northwest Power Planning Council 2001b). In 1902 a hatchery on the Grande Ronde located near the mouth of the Wenaha River collected 7.5 million coho eggs from 2,655 adults (Van Cleve and Ting 1960). Snake River coho have been considered extinct since the early 1980s (Petersen 2001, Northwest Power Planning Council 2001c). The Nez Perce Tribe is using coho stock from the lower Columbia River in an attempt to reestablish a coho run in the Clearwater River of Idaho (Army Corps of Engineers 1999) (See Figure 2 and Figure 3).

Sockeye

Sockeye *(O. nerka)* were listed under the ESA as an endangered species on November 20, 1991. Since the late 1980's sockeye have only returned to Redfish Lake, one of five lakes in the Sawtooth Basin of the Salmon River, Idaho that historically reared sockeye (National Marine Fisheries Service 1991, Taki *et al.* 1999). The NMFS began a captive broodstock program with one female and three males captured in 1991. In 1910, the Sunbeam Mining Company built a dam across the Salmon River twenty miles downstream from Redfish Lake. Fish ladders were incorporated, but they appeared ineffective. In 1934, the dam was abandoned and local residents blew it up with dynamite. The Idaho Department of Fish and Game poisoned the sockeye lakes for several decades in an attempt to reduce competition between sockeye and Kamloops rainbow trout. Toxaphene was applied to Stanley, Pettit, and Yellowbelly Lakes in 1959, 1961, and 1962 respectively. Redfish Lake sockeye persisted with a spawning return of 4,400 fish in 1960 (Dietrich 1997). From 1990 to 1997 only 15 sockeye returned to Redfish Lake. Passage barriers were removed from the outlets of Pettit and Alturas Lakes in 1995 and 1997 respectively. Sockeye from the captive broodstock program have been released in Redfish, Pettit, and Alturas Lakes (Taki *et al.* 1999). The Snake River mainstem (WRIAs 33 & 35) is a migration corridor as sockeye migrate to and from the ocean. See Map 21 and Map 22 for the current sockeye distribution. See Table 7 for sockeye usage of individual stream reaches (See Figure 2 and Figure 3).

Steelhead/Rainbow Trout

Steelhead/rainbow trout *(O. mykiss)* are the most widely distributed salmonid in WRIA 35. They are found throughout the majority of the basin's streams (Washington Department of Fisheries and Washington Department of Wildlife 1993). The Grande Ronde, Asotin, and Tucannon Subbasins are the primary steelhead production areas. However, small populations are found in independent tributaries of the Snake River including: Couse, Tenmile, Alpowa, WaWawai, Almota, Little Almota, Penawawa, Deadman, Meadow, and Alkali Flat Creeks. See Map 23 and Map 24 for the current steelhead/rainbow trout distribution. Hatchery fish from Idaho, Oregon, and the USFWS are also present in the Snake River mainstem (Mendel 2002a, personal communication). Estimated escapements from 1987 through 1999 on the Tucannon River ranged from 71 to 525 wild steelhead (See Table 3). Lyons Ferry stock steelhead are currently released in the Tucannon, but a switch to local broodstock is underway. The broodstock will be used for supplementation and to enhance the natural population (Mendel 2002a, personal communication). On Asotin Creek estimated escapement for 1988 through 1992 was less than or equal to the WDFW management goal of 160 fish annually. See Table 4 for Asotin Creek steelhead redd counts from 1988 to 2001. Spawning ground surveys were not conducted regularly on the Grande Ronde River and tributaries in Washington (Washington Department of Fisheries and Washington Department of Wildlife 1993). See Table 5 for steelhead redd counts on WRIA 35 minor tributary streams for 2000 and 2001. Snake River steelhead were listed as threatened under the ESA in August 1997 (National Marine Fisheries Service 1999). The Snake River mainstem through WRIA 33 is a migration corridor for steelhead from tributary streams in WRIA 35, Oregon, and Idaho. See Table 7 for steelhead usage of individual stream reaches (See Figure 2 and Figure 3).

Table 3. Tucannon River steelhead escapement, Marengo to Sheep Creek 1987 to 2000.

Year	Wild	Hatchery	Total	Year	Wild	Hatchery	Total
1987[a]	521	750	1271	1994[a]	151	96	247
1988[a]	525	787	1312	1995[a]	147	230	377
1989[a]	319	388	707[1]	1996[a]	71	322	393[2]
1990[a]	416	343	759[1]	1997[a]	N/A	N/A	N/A
1991[a]	210	256	466[1]	1998[a]	N/A	N/A	N/A
1992[a]	166	513	679	1999[a]	85	340	425
1993[a]	94	475	569	2000[b]			230[3]
				2001[b]			412[3]

Notes: 1. Estimated from juvenile index counts of "fry" that resulted from uncounted spawners. 2. Panjab Creek not included. 3. Redds counted from U.S. Hwy. 12 to Sheep Creek. (a) Data from WDFW Snake River Lab published in (Northwest Power Planning Council 2001e). (b) (Schuck 2002, personal communication). N/A = Not available.

Table 4. Asotin Creek steelhead redd counts 1988 to 2001. Areas surveyed varied from year to year.

	Asotin Creek Stream							
	North Fork		South Fork		Charley Creek		Mainstem	
Year	Observed	*Expanded*	Observed	*Expanded*	Observed	*Expanded*	Observed	*Expanded*
1988	72	N/A	88	N/A	37	N/A	15	N/A
1989	25	N/A	21	N/A	13	N/A	—	N/A
1990	17	N/A	17	N/A	0	N/A	—	N/A
1991	26	N/A	0	N/A	10	N/A	—	N/A
1992	27	27	23	23	19	19	3	3
1993	34	N/A	50	50	8	N/A	—	—
1994	22	33	11	17	8	N/A	4	N/A
1995	66	N/A	32	N/A	12	N/A	—	—
1996	53	N/A	65	N/A	—	—	—	—
1997	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
1998	32	N/A	19	N/A	3	N/A	N/A	N/A
1999	36	85	11	36	15	23	26	102
2000	9	33	16	34	16	21	25	60
2001	91	105	33	33	43	44	199	205

Note: Expanded values equal observed values adjusted to account for observer efficiency. Data from WDFW Snake River Lab, published in (Northwest Power Planning Council 2001a). N/A = Not available.

Table 5. Steelhead redd counts in WRIA 35 minor tributary streams 2000 and 2001. Areas surveyed varied from year to year.

	Year	
Stream	2000	2001
Asotin Tributaries		
George Creek	21	42
Coombs Creek	2	2
Hefflefinger Creek	0	1
Pintler Creek	6	N/A
Snake Tributaries		
Tenmile Creek	36	29
Couse Creek	6	0
Steptoe Creek	N/A	0
Wawawai Creek	N/A	1
Almota Creek	N/A	25
Little Almota Creek	N/A	0
Deadman Creek	N/A	9
North Deadman Creek	N/A	0
South Deadman Creek	N/A	0
Meadow Creek	N/A	0
North Meadow Creek	N/A	0

Notes: 2000 data from (Mendel *et al.* 2001). 2001 data from (Mendel 2001, unpublished work).
N/A = Not available.

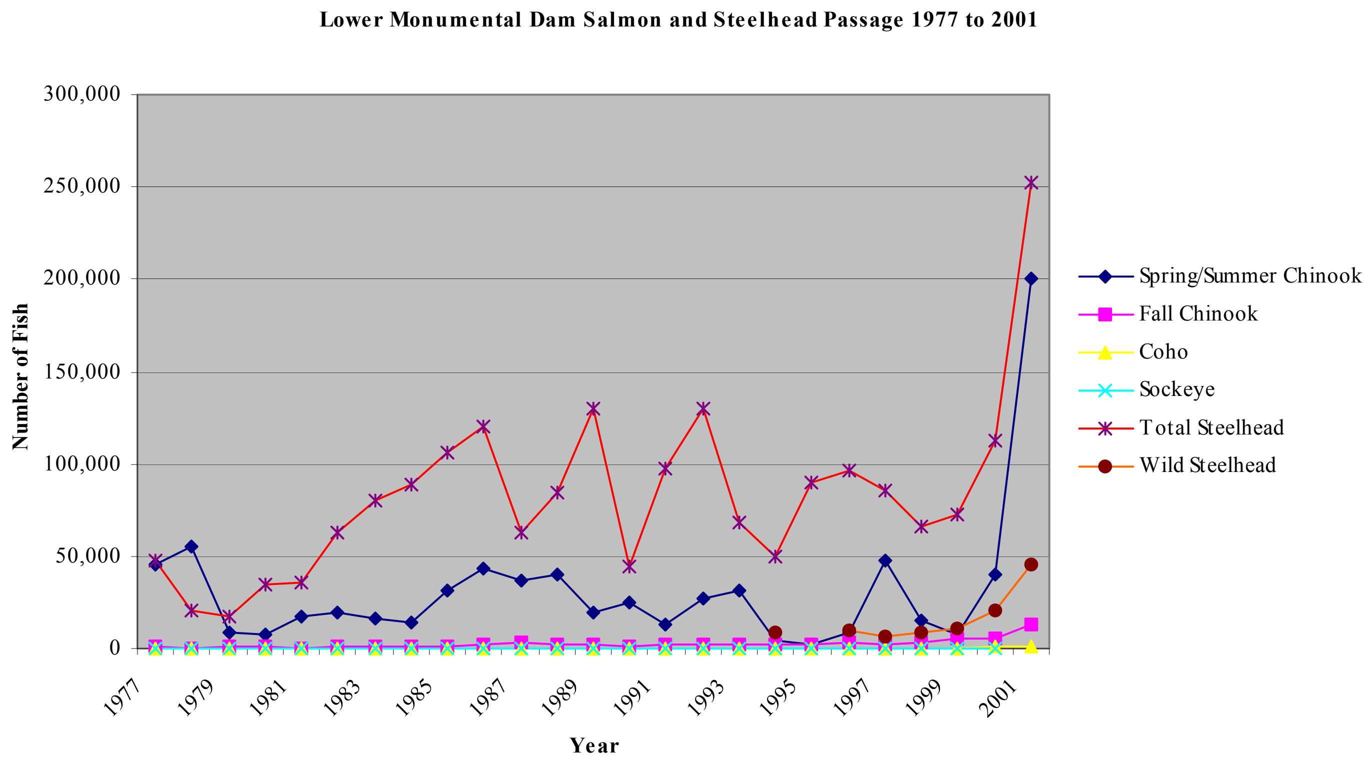

Figure 2. Adult salmon and steelhead passage at Lower Monumental Dam (RM 42 Snake River) from 1977 to 2001. Source: (Fish Passage Center 2001a, Fish Passage Center 2001c). Note: salmon counts do not include jacks. Wild Steelhead were not differentiated until 1993 and are a subset of the total steelhead count. 2001 data are preliminary. Note: counting periods differ at Lower Monumental and Lower Granite Dams, accounting for higher numbers of fish counted at Lower Granite than downstream at Lower Monumental.

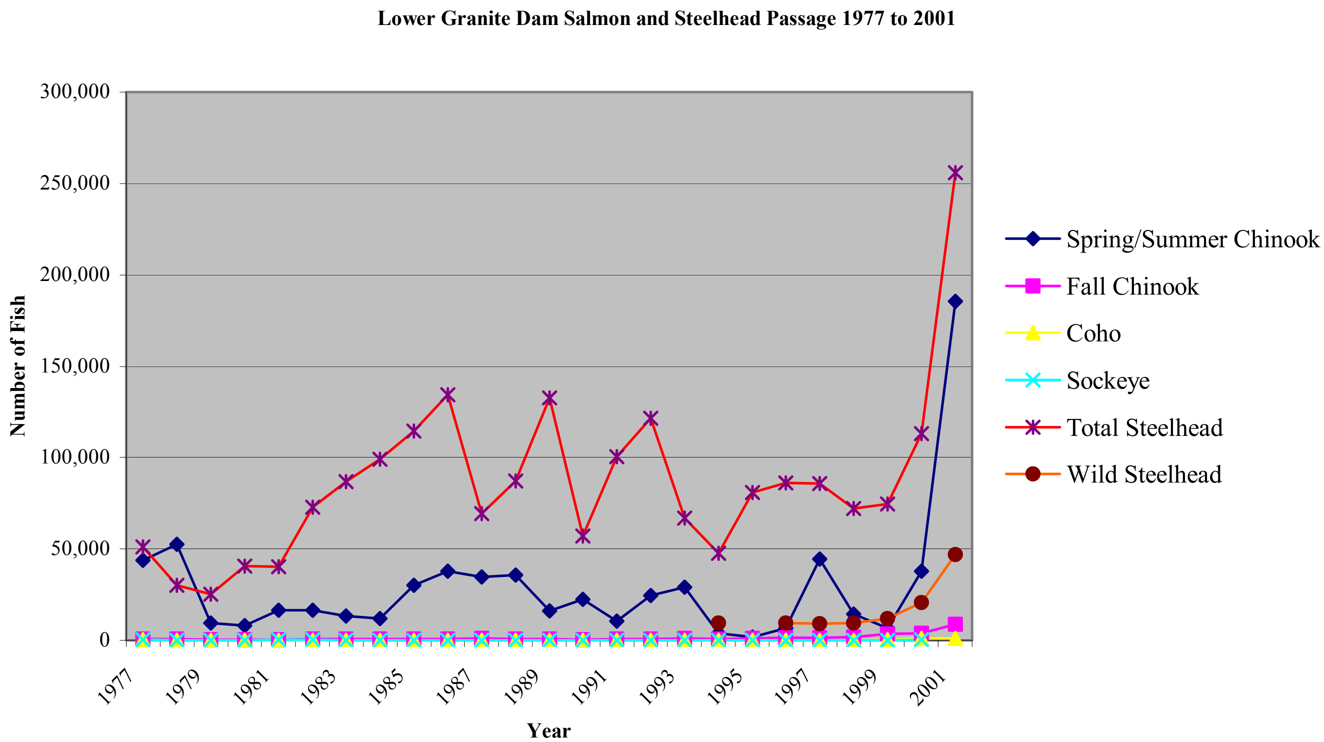

Figure 3. Adult salmon and steelhead passage at Lower Granite Dam (RM 107 Snake River) from 1977 to 2001. Source: (Fish Passage Center 2001a, Fish Passage Center 2001b). Note: salmon counts do not include jacks. Wild Steelhead were not differentiated until 1993 and are a subset of the total steelhead count. 2001 data are preliminary. Note: counting periods differ at Lower Monumental and Lower Granite Dams, accounting for higher numbers of fish counted at Lower Granite than downstream at Lower Monumental.

Bull Trout

Bull trout *(Salvelinus confluentus)* are present in the Grande Ronde, Asotin, Tucannon, and Snake Subbasins of WRIA 35 as well as the Snake River mainstem in WRIA 33. The Grande Ronde and Tucannon populations include fluvial and/or adfluvial life history strategies, while the Asotin Creek population is believed to be primarily resident fish (Washington Department of Fish and Wildlife 1998, TAG 2001, personal communication). Spawning and rearing are confined to headwater areas of the Grande Ronde, Asotin, and Tucannon Watersheds. Tributary streams of the Wenaha River (Crooked Creek, Butte Creek, Milk Creek, Beaver Creek, and North Fork Wenaha River) are the primary spawning and rearing areas in the Grande Ronde Subbasin within Washington. Asotin Creek bull trout spawning and rearing occurs above Charley Creek, and is suspected to occur in upper George Creek. Spawning and rearing in the Tucannon is restricted to the mainstem and tributaries, primarily above Panjab Creek (Mendel 2001, personal communication). The Tucannon population is characterized as healthy based on spawning ground surveys and juvenile densities. The status of Asotin Creek bull trout is unknown, but may be critical based on very low abundance. See Table 6 for bull trout redd counts on the Tucannon River and Asotin Creek from 1991 to 2000. The Wenaha bull trout population may be one of the healthiest populations in Oregon because of the remote location in the Wenaha-Tucannon Wilderness Area and a current distribution likely comparable to the historic distribution (Buchanan *et al.* 1997). Columbia River bull trout were listed as threatened under the ESA in June 1998 (Fish and Wildlife Service 1998). Bull trout have been documented at all four lower Snake River Dams (Underwood *et al.* 1995, Baxter 2002). Snake and Grande Ronde River bull trout recovery plans are currently under development. Additional information will be available once the reports are completed (Mendel 2002a, personal communication). See Table 7 for bull trout usage of individual stream reaches. See Map 25 and Map 26 for the current bull trout distribution.

Table 6. Tucannon River and Asotin Creek bull trout redd counts 1991 to 2000.

Year	Number of Bull Trout Redds		
	Tucannon River	Asotin Creek	
		North Fork	Cougar Creek
1991	57	N/A	N/A
1992	66	N/A	N/A
1993	N/A	N/A	N/A
1994	131	N/A	N/A
1995	114	N/A	N/A
1996	184	3	N/A
1997	78	N/A	N/A
1998	108	N/A	N/A
1999	222	53	15
2000	151	N/A	N/A

Note: Tucannon data from (Northwest Power Planning Council 2001e). Asotin Creek data from (Northwest Power Planning Council 2001a).

Table 7. Fish presence in WRIAs 33, 34, and 35.

Key: K = Known presence, P = Presumed presence, R = Rearing use, SR = Spawning and rearing use, M = Migration use, H = Potential/historic use
Note: (a) Summer steelhead includes rainbow/redband trout.

Stream Name	Summer Steelhead[a]	Bull Trout	Mountain Whitefish	Spring Chinook	Fall Chinook	Sockeye	Smallmouth Bass	Sturgeon
Grande Ronde Subbasin								
Grande Ronde Mainstem: Washington portion	K, SR	K, MR	M	M	K, SR		K, SR	H
Grande Ronde Tributaries: Washington portion	K, SR	K[1]						
Wenaha River Tributaries: within Washington	K, SR	K, SR	K, SR	K, SR				
Tenmile-Couse Subbasin								
Couse Creek	K, SR							
Tenmile Creek: Headwaters to Mill Creek	K, SR							
Tenmile Creek: Mill Creek to Mouth	K, SR							
Asotin Subbasin								
North Fork Asotin Creek	K, SR	K, SR		K?H				
South Fork Asotin Creek	K, SR	H		K?				
Asotin Creek: Forks to George Creek	K, SR	H						
Asotin Creek: George Creek to Mouth	M	H						
Charley Creek	K, SR	K?						

Table 7. Continued.

Key: K = Known presence, P = Presumed presence, R = Rearing use, SR = Spawning and rearing use, M = Migration use, H = Potential/historic use
Note: (a) Summer steelhead includes rainbow/redband trout.

Stream Name	Summer Steelhead[a]	Bull Trout	Mountain Whitefish	Spring Chinook	Fall Chinook	Sockeye	Smallmouth Bass	Sturgeon
Asotin Subbasin Cont'd.								
George Creek: Headwaters to Wormell Creek	K, SR	H?						
George Creek: Wormell Creek to Mouth	K, SR							
Pintler Creek	K, SR							
Alpowa-Deadman Subbasin								
Alpowa Creek: Headwaters to Stember Creek	K, SR							
Alpowa Creek: Stember Creek to Mouth	K, SR		R	H?				
Meadow Creek	K, SR							
North and South Deadman Creeks	K, SR							
Deadman Creek: Forks to Mouth	K, SR							
Tucannon Subbasin								
Tucannon River: Headwaters to Panjab Creek	K, SR	K, SR	K, SR	K, SR				
Tucannon River: Panjab Creek to Marengo	K, SR	K, RM	K, SR	K, SR				
Tucannon River: Marengo to U.S. Hwy. 12	K, SR	K, RM	K?	M				
Tucannon River: U.S. Hwy. 12 to Mouth	K, SR	M		M	K, SR		K	

Table 7. Continued.

Key: K = Known presence, P = Presumed presence, R = Rearing use, SR = Spawning and rearing use, M = Migration use, H = Potential/historic use
Note: (a) Summer steelhead includes rainbow/redband trout.

Stream Name	Summer Steelhead[a]	Bull Trout	Mountain Whitefish	Spring Chinook	Fall Chinook	Sockeye	Smallmouth Bass	Sturgeon
Tucannon Subbasin Cont'd.								
Pataha Creek Headwaters to Columbia Center	K, SR							
Pataha Creek: Columbia Center to Pomeroy	K, SR							
Pataha Creek: Pomeroy to Mouth	M							
Snake Mainstem Subbasin								
Snake River: WA/OR Stateline to City of Asotin	K, M, SR?	M, R	K	M	K, SR	M	K, SR	M
Snake River: City of Asotin to Palouse River	M	M, R	K	M	K, SR	M	K, SR	K
Snake River Fish Bearing Tributary Streams	K, SR							
Snake River: Palouse River to Mouth (WRIA 33)	M	M, R	K	M	K, M, SR	M	K, SR	K
Palouse River Below Palouse Falls (WRIA 34)								
Palouse River Below Palouse Falls	K	K			K, SR		K	

Notes: 1. Bull trout are known to be present in Menatchee Creek only.

HABITAT LIMITING FACTORS IDENTIFICATION

This report was developed by synthesizing written habitat descriptions, data derived from field assessments of habitat, and personal communications from natural resource professionals with knowledge of the Middle and Lower Snake Watersheds. Many of these personnel served in various capacities on the Technical Advisory Group (TAG), which contributed large amounts of literature, data, and technical review to this project. This report is intended for use as a tool to guide and prioritize salmonid habitat restoration projects ***on tributary streams*** in the Middle Snake Watershed and the Palouse River mainstem below Palouse Falls. No salmonid bearing tributary streams are present in the Lower Snake Watershed; therefore, with the exception of fish passage, habitat conditions were not evaluated. Habitat descriptions, assessments, and TAG knowledge were used to describe the current habitat conditions on river reaches throughout the region. These descriptions were compared to the southeast Washington salmonid habitat rating criteria (Table 9), resulting in a good, fair, or poor rating for habitat quality averaged throughout the length of each river reach (Table 10). **"Biological Processes" will receive a FAIR rating at best because of a lack of anadromous fish carcasses and a depressed beaver population throughout the region.** A summary of habitat limiting factors is found in (Table 11). The habitat descriptions and ratings were used to develop recommendations for each subbasin in this report. These recommendations are not intended as regulatory mandates. They are actions that are necessary to restore salmonid populations in the Snake River Region. Implementation of some of the recommendations will require creative thinking, compromise, and in some cases sacrifices. It should be up to the people living in the watershed to decide whether or not these recommendations will be implemented. Salmon recovery will not be successful unless the public supports restoration efforts.

Comments on Data

This report is a compilation of data gathered from multiple entities. In many cases, the entities used different methods during habitat assessments. For example, the U.S. Forest Service typically used the Hankin and Reeves method of assessing stream habitat. With this methodology, pool length must be greater than or equal to the stream width to be counted as a "pool." The entire length of a reach is assessed with this method (Forest Service (USDA) 1996). Small pocket pools such as those typically encountered in high gradient tributary streams are not counted (i.e. pool frequency is often underestimated). The Bureau of Fisheries (now National Marine Fisheries Service, NMFS) conducted the earliest stream surveys in southeast Washington (McIntosh *et al.* 1989b). Their survey protocol inventoried everything from "small pools in cascades" up to pools greater than six-feet deep with a surface area greater than 450 square-feet. Streams were evaluated at approximately 100-yard intervals with this method (McIntosh *et al.* 1989a). The Natural Resource Conservation Service (NRCS) assessed Asotin Creek in the summer of 2000. Their study characterized pools as having a minimum depth of 1-foot deep. They also included three categories of "large pools" (Natural Resources Conservation Service (USDA) 2001). The Washington Department of Fish and Wildlife (WDFW) typically defines a pool as having a minimum depth of 0.5-feet (Mendel 2001, personal communication).

Prior to 1996 the U.S. Forest Service included "leaning woody debris" (trees leaning over the stream channel that had the potential to fall into the channel in the near future) in large woody debris (LWD) counts (for example, (Forest Service 1992h, unpublished work). Because of this, LWD counts reported by the Forest Service prior to 1996 are likely overestimates. From 1996 to the present only woody debris located within the stream's bankfull channel was counted (Forest Service (USDA) 1996). Substantial amounts of data were gathered prior to the 1996-97 floods.

The floods dramatically altered habitat in most southeast Washington streams. Conditions often improved in headwater tributary streams where LWD and pool numbers increased, and substrate embeddedness decreased (Groat 2001, personal communication). However, in mid-and low elevation stream reaches conditions often deteriorated. Flood flows confined by bank armoring, dikes, and bridge abutments along with later flood repairs caused bank erosion, loss of sinuosity, and destruction of riparian vegetation (Columbia Conservation District 1997, TAG 2001, personal communication, Northwest Power Planning Council 2001a). Information collected prior to the floods may not accurately reflect current habitat conditions. Readers interested in late 1970s to early 1990s habitat conditions are encouraged to consult the following reports: (Vail 1979, Ransom *et al.* 1980, Mendel and Taylor 1981, Mendel 1984, Hallock and Mendel 1985, Schuck and Mendel 1986, Schuck and Mendel 1987, Schuck *et al.* 1988, Viola *et al.* 1991).

Habitat Limiting Factors Assessed

<u>Fish Passage</u>

Artificial obstructions including dams and culverts can block salmonid migration up and down streams. Depending on the location and longevity of the barrier, the negative effect may be limited to a portion of only one generation, or in extreme cases, the barrier may cause the extinction of an entire run of fish. Manmade structures that may hinder salmonid migration in WRIAs 33, 34, and 35 include concrete dams, gravel push-up dams, and failed culverts. Natural waterfalls are common in headwater areas within the Blue Mountains (See Figure 4).

Figure 4. Lower Granite Dam RM 107 Snake River. Photographed September 2001.

Screens and Diversions

Diversions can take a serious toll on salmonid populations during the juvenile portion of the life history. Juvenile salmonids seek out off-channel areas for rearing habitat. These areas typically provide hiding cover from predators, calmer water, and abundant food sources. The opening to a gravity diversion closely resembles an off-channel area. Juvenile salmonids may swim into this entrance if it is not blocked by a proper screen. From this point, the fish may get trapped, become an easy meal for predators, or get sucked up in irrigation equipment and pumped onto a field. Pump style diversions also need adequate screening to ensure that juvenile salmonids are not sucked into the irrigation system.

Riparian Condition

Riparian zones are the interface between the aquatic and terrestrial environments. This zone is normally covered with lush vegetation ranging in composition from grasses and forbs to shrubs and large trees depending upon the location within a watershed. Historically riparian zones in southeast Washington were dominated by large cottonwood trees in the low to mid-reaches of Snake River tributary streams. Coniferous trees such as pine and fir tend to dominate with an increase in elevation and proximity to the Blue Mountains (Asotin County Conservation District 1995, Columbia Conservation District 1997). The Snake River mainstem had limited riparian vegetation, primarily composed of shrubs (Coues 1893). Riparian zones have several important functions in maintaining natural riverine processes. Tree and shrub roots hold streambanks together (Montgomery and Buffington 2001) with a "root matrix." This matrix stabilizes channels, enabling the formation of undercut banks (excellent fish habitat) and reduces erosion (fine sediment smothers juvenile salmonids developing in streambed gravels) (Bjornn and Reiser 1991). Overhanging tree canopies shade water (Naiman *et al.* 2001), maintaining the cool temperatures salmonids need to thrive (Bjornn and Reiser 1991).

Leaf litter falling into the stream is an important component of primary production within the aquatic community (Bisson and Bilby 2001), although Murphy (2001) asserts that production by aquatic plants and algae makes a larger contribution. Microinvertebrates (i.e. zooplankton) and macroinvertebrates (larval insects, aquatic snails, etc.) feed on the decomposing organic material. Fish and other animals in turn feed on the smaller organisms (Bisson and Bilby 2001). Mature trees in the riparian zone also provide important function when they are knocked into streams by floods, windthrow, or landslides. These woody materials are known as large woody debris (LWD). Large woody debris stabilizes streambeds and banks, captures spawning gravels, encourages pool formation, provides resting and hiding cover for salmonids, and creates habitat for insects and other forage important to salmonids (Bilby and Bisson 2001). Finally vegetation within the riparian zone filters soil and pollutants from stormwater runoff (Knutson and Naef 1997, Welch *et al.* 2001) and reduces flood damage by slowing down flood waters, thereby dissipating energy and capturing soil carried in the flood waters (Naiman *et al.* 2001) (See Figure 5).

Figure 5. Riparian vegetation on lower First Creek showing bank stabilization, overhanging cover, and shading – July 1994. Photo courtesy of U.S. Forest Service, Pomeroy Ranger District.

Streambank Condition

Natural streambank stability maintains the integrity of river processes. Riparian zones can maintain or repair themselves if they are located on a stable bank. Vegetation has a difficult time recovering from flood damages or other disturbances if it is continually undermined by a failing bank (Naiman *et al.* 2001). Stable streambanks also ensure an adequate channel depth. A given volume of water is deeper in a narrow channel than in a wide channel. Depth maintains the cool temperatures and hiding cover needed by salmonids. Rapidly eroding banks tend to lead to development of overly wide and shallow channels (Platts 1991). Eroding streambanks can contribute large amounts of fine sediment to the water column (See Figure 6) as well as large amounts of coarse sediment that is deposited in the stream channel (aggraded), thus leading to subsurface flows (Hicks *et al.* 1991, Ziemer and Lisle 2001). Fine sediment appears to have little negative effect on adult salmonids (unless levels are chronically high), but it smothers developing juvenile salmonids buried in bottom substrate and fills interstitial spaces in between gravels, cobbles, and boulders that provide important winter cover (Bjornn and Reiser 1991) (See Substrate Embeddedness).

Figure 6. Braided stream reach on Couse Creek above RM 2. Photographed October 2001.

Floodplain Connectivity

Floodplains provide an area for dissipation of energy in flood waters. The floodplain has a larger surface area, and generally flatter slope than the stream channel. Once flood waters spill onto the floodplain, the water spreads out, loses energy, and deposits fine sediment. Collisions between water and riparian vegetation reduce energy even further. Confining streamflow through channelization, and diking increases stream energy (and the potential for serious flooding downstream) by negating the benefits of water dispersing onto the floodplain (Ziemer and Lisle 2001) (See Figure 7). Off-channel areas provide both adult and juvenile salmonids refugia during floods (Benda *et al.* 2001), and may be used by rearing salmonids for long periods of time depending upon species (See Off-Channel Habitat). Functional floodplains moderate instream flow peaks by substantially increasing the area available for water storage (Ziemer and Lisle 2001). Water seeps into the groundwater table during floods, recharging wetlands, off-channel areas and shallow aquifers. Wetlands and aquifers in turn release water to the stream during the summer months through a process called hydraulic continuity. This maintenance of flow ensures adequate flows for salmonids during the summer months, and reduces the possibility of high-energy flood events that can destroy salmonid redds during the winter months.

Figure 7. Walla Walla River downstream from Milton Freewater, OR 1965. Floodwaters burst through the dikes attempting to reestablish a meandering channel and reclaim the floodplain. Photo courtesy of U.S. Army Corps of Engineers, Walla Walla District.

<u>Width/Depth Ratio</u>

The width/depth ratio refers to the average width of the river channel at a given cross-section divided by the average depth at that same cross-section. In other words, it determines if the channel is wide and shallow (high width/depth ratio) or narrow and deep (low width/depth ratio). In general, a narrow deep channel is more favorable to salmonids than a wide shallow channel. Deep water provides hiding cover and maintains cool water temperatures, while shallow water provides little or no cover (depending upon the life stage) and tends to gather heat with an expansive surface area exposed to the sun. The width/depth ratio also provides clues about a river's current state of channel evolution. A low width/depth ratio indicates a stable channel that has reached the end point of channel evolution, or possibly an unstable channel that is downcutting rapidly in response to channel disturbances elsewhere within the watershed. Conversely, a very high width/depth ratio usually indicates unstable streambanks and rapid deposition of sediments. This situation might naturally occur at a river outlet or delta area, or it could be a response to channel disturbances upstream or downstream (Rosgen 1996) (See Figure 8).

Figure 8. Channel incision on Lower Lick Creek, July 1996. Photo courtesy of U.S. Forest Service, Pomeroy Ranger District.

Substrate Embeddedness

Substrate embeddedness is the product of fine sediment washed into streams. Soil eroded from cropland, forestland, urban developments, and roads is the main source of fine sediment inputs to streams in southeast Washington. However, unstable stream banks also make significant contributions. Ideal salmonid spawning habitat has very little substrate embeddedness (See Figure 9). When fine sediment settles to the bottom it cements gravels and cobbles together forming a type of "pavement." This pavement makes it difficult for female salmonids to excavate their nest or redd. Highly embedded substrate also prevents juvenile or sub-adult salmonids from entering of exiting interstitial spaces in the substrate that provide important winter cover. An abundance of fine sediment reduces the amount of water able to circulate through the gravel deposited over the eggs in the redd. This water infiltration is critical to oxygen delivery to the developing salmonids and removal of fish wastes from the nest (Hicks *et al.* 1991, Bjornn and Reiser 1991).

Figure 9. Clean-unembedded gravel provides excellent salmonid spawning habitat.

Large Woody Debris

Large woody debris or (LWD) is an important component of stream habitat. Large trees that fall into streams, or are carried in by landslides and floods stabilize streambeds, collecting spawning gravels and encouraging pool formation. Woody debris also provides cover for salmonids and their prey (See Figure 10). In the past woody debris was removed to aid navigation, transport logs downstream, speed floodwaters downstream, or remove barriers to salmonid migration. Large woody debris is lacking in many streams because of these activities (Sedell *et al.* 2000) and the reduction or modification of riparian vegetation. Unfortunately woody debris recruitment is a long-term process since it first requires the presence of a functioning riparian zone comprised of large trees, and second, a means of getting the tree into the stream (i.e. flood, wind storm, landslide, beaver falling a tree, etc.) (Benda *et al.* 2001).

Figure 10. Large woody debris providing complex instream cover on lower First Creek – July 1994. Photo courtesy of U.S. Forest Service, Pomeroy Ranger District.

Pool Frequency

Pools are important habitat for salmonids and their prey. Salmonids use pools for resting during migration, rearing, hiding cover, feeding, and spawning in tailouts or current edges. Pools are characterized by calm water and can range in size from one foot deep and a few feet of surface area to 10 feet or greater in depth with a substantial surface area depending upon the size of the stream.

Pool Quality

Important features of pools are size, depth, and cover (instream and overhead). Generally speaking, the more size, depth, and cover that are present, the higher the quality of the pool. Large-deep pools with lots of cover provide many hiding areas, ample forage, and cool water temperatures. An abundance of pools interspersed with riffles combine to create ideal salmonid habitat (See Figure 11).

Figure 11. Very large and deep pool on Grande Ronde River upstream from Schumaker Creek. Photographed October 2001.

Off-Channel Habitat

Beaver ponds, wetlands, oxbow ponds, and side channels connected to the main river channel are all forms of off-channel habitat. Juvenile salmonids (especially coho salmon, rainbow/steelhead trout, and cutthroat trout) seek out this type of habitat for rearing. Off-channel areas provide an abundance of food with fewer predators than would typically be found in the river. These areas also generally have reduced current and large amounts of vegetative and/or woody cover, allowing juvenile salmonids to hide from predators and conserve energy (See Figure 12). Diking, and channelization of rivers, conversion of riparian zones to pasture and cropland, floodplain development, and extermination of beaver all play a roll in destruction of off-channel habitat.


Figure 12. Beaver ponds provide excellent off-channel rearing habitat for salmonids. Today beaver populations are depressed in southeast Washington. Photo was taken in western Washington.

Water Quality/Temperature

Salmonids require cold and clean water for optimal survival. Temperature, dissolved oxygen (DO) concentration, total suspended solids (TSS), pH, and other variables are all important elements of water quality. Water temperature requirements vary depending upon salmonid lifestage and species, but in general, a range of 50-65°F (10-21°C) is preferred (bull trout need even colder water in the range of 36-54°F (2-12°C)). Long-term exposure to temperatures greater than 75°F (24°C) is fatal to salmonids (Bjornn and Reiser 1991). Salmonids require a minimum dissolved oxygen concentration of 5 mg/L (also read as [ppm] or parts per million) for survival (Bjornn and Reiser 1991). Washington State water quality standards require a value of eight mg/L of dissolved oxygen for protection of fish resources in Class A or better waters (WAC 173-201A). Total suspended solids (TSS) refers to the weight of particles including soil, and algae suspended in a given volume of the water column (Michaud 1991). The U.S. Fish and Wildlife Service recommends a maximum TSS level of 80 mg/L to protect salmonid fishes (Fish and Wildlife Service 1995). Other water quality parameters including pH (the concentration of hydrogen ions in water), and chemical pollution can degrade habitat quality.

Water Quantity/Dewatering

Southeast Washington has a semi-arid climate with the majority of precipitation occurring in the winter months. Stream flows are dependent on the snow pack in the Blue Mountains. The summer months bring naturally low stream flows that are further reduced by irrigation water withdrawals on some streams. The natural climate, degraded watershed conditions, and human actions may all contribute to low and/or subsurface flows. If flows are too low or channels are completely dewatered, little or no quality habitat remains for salmonids. As flows decrease, water temperatures usually increase. Migration is hindered or completely blocked and fish are more vulnerable to predation (See Figure 6).

Change in Flow Regime

A change in flow regime refers to the current flow conditions affected by human management versus the natural flow conditions that were present in the watershed prior to Euro-American settlement. It is possible to infer that a change in flow regime has occurred on many reaches because water is removed for irrigation purposes. However, in many cases it is not possible to determine the magnitude of the flow regime change.

Biological Processes

Biological processes include the presence of introduced plant or animal species that may have a negative effect on salmonids (i.e. reed canary grass, brook trout, smallmouth bass) as well as the absence of native species that were historically present such as beaver and coho salmon. Introduced plants and noxious weeds can out-compete native vegetation, reducing the quality of riparian plant communities (Knutson and Naef 1997) and increasing the frequency and/or intensity of fires. Introduced fish species may out-compete, hybridize with, or eat native salmonids. Removal of species can disrupt ecosystem functions (McClain *et al.* 2001). For example, beaver were historically more numerous in southeast Washington. Beaver ponds are excellent salmonid rearing habitat and they gradually release water to streams, helping to maintain summer flows (Lichatowich 1999). Anadromous salmonids returning from the ocean are a valuable source of nutrients to watersheds which are often nutrient limited (McClain *et al.* 2001). Nutrients from decomposing salmon carcasses are a critical component of aquatic (Bisson and Bilby 2001) and terrestrial food webs (Reeves *et al.* 2001). Adult anadromous fish escapements are severely below historic levels in southeast Washington streams (Mendel 2001, personal communication) (See Figure 13).

Figure 13. Decomposing anadromous fish carcasses provide ocean-derived nutrients to freshwater ecosystems. Photo taken in western Washington.

Grande Ronde Subbasin Description

The Grande Ronde Subbasin encompasses the Grande Ronde River and all portions of tributary streams within the State of Washington (approximately 340 square miles, 184 sq. miles on the Grande Ronde mainstem and 156 sq. miles in the Wenaha drainage). The highest point in the subbasin is Diamond Peak at 6,380 feet elevation. The Grande Ronde River enters the Snake River at (RM 168.7) at about 1,400 feet elevation (See Map 11). Dryland agriculture and livestock grazing are the dominant land uses in mid-elevation upland areas, while forestry and grazing are the dominant land uses at higher elevations. Recreation (hunting, fishing, berry picking, wood cutting, float trips, etc.) is a major activity on public and private lands at all elevations (Mendel 2001, personal communication). The Wenaha portion of the subbasin is protected by the Wenaha-Tucannon Wilderness Area. The subbasin is characterized by deep v-shaped valleys (See Figure 14). The topography is the result of folding and faulting of extensive deposits of Columbia River Basalts. Highly erodible loess soils on the plateau tops support some dryland farming, but livestock grazing is the primary land use outside of the Wenaha-Tucannon Wilderness Area. Currently 400 acres of cropland are enrolled in the CRP (Johnson 2001, personal communication). There is generally a large difference in elevation between the valley bottom and surrounding plateaus.

Four hundred fifty-four miles of perennial streams (188 miles Wenaha Watershed, 266 miles Grande Ronde Watershed) are present within the Washington portion of the Grande Ronde Subbasin (Washington State Conservation Commission and Northwest Indian Fisheries Commission 2001, unpublished work). Intermittent and/or ephemeral streams are present throughout the watershed. These streams flow down very steep canyons and under typical conditions do not convey much water, but during thunderstorms or rain-on–snow events they are capable of carrying immense debris torrents into the Grande Ronde River. The sediment moving capacity of these small streams is easily seen in the extensive alluvial fans deposited at their mouths. Habitat conditions in the Grande Ronde Subbasin are generally fair to good (See Table 10).

Summer steelhead, spring chinook, fall chinook, resident rainbow trout, bull trout, white fish, and sturgeon are currently present in the subbasin. Coho were historically present, but were extirpated by 1985 (Northwest Power Planning Council 2001b). Salmonid bearing streams in the subbasin include the North Fork Wenaha River, Deep Saddle Creek, Beaver Creek, Butte Creek, East and West Forks Butte Creek, Rainbow Creek, Crooked Creek (and many tributary streams), Grouse Creek, Menatchee Creek and its West Fork, Bear Creek, Cougar Creek, Cottonwood Creek, Rattlesnake Creek and its West Fork, Schumaker Creek, and Joseph Creek. Summer steelhead are presumed to be present in Buford and Deer Creeks (See Appendix B).

Figure 14. Grande Ronde River Canyon looking downstream toward Schumaker Creek. Photographed October 16, 2001.

Grande Ronde River Mainstem (within Washington)

Habitat Ratings

Fish Passage

No barriers are known to exist on the mainstem Grande Ronde within Washington. However, "the Narrows, " a basalt chute just upstream from the confluence of Joseph Creek, may be a barrier during certain flows. Low summer flows and high water temperatures as well as high turbidity during high intensity runoff events may hinder migration. The Grande Ronde is somewhat unique in southeast Washington in the formation of thick ice sheets during the winter months. Ice jams form when the ice sheets break up, and coupled with shallow water may occasionally block fish passage. (Mendel 2001, personal communication).

Screens and Diversions

One pump diversion is known to be in use on the reach upstream from Washington State Route 129. Compliance with NMFS screening requirements is unknown (Kuttel 2001b).

Riparian Condition

Grasses and a few small shrubs are the dominant riparian vegetation along the majority of this reach. The Grande Ronde flows through a very deep basalt canyon that constrains the channel. Because of this, floodplains are rare and generally small where present. Riparian vegetation such as trees and shrubs is naturally limited by the narrow valley bottom and arid climate. An occasional pine is the dominant tree species along this reach (Kuttel 2001b). Grazing and roads limit riparian vegetation along portions of the reach. Debris torrents from tributary streams and ice flows on the mainstem also have the potential to damage and/or remove riparian vegetation (Mendel 2001, personal communication).

Streambank Condition

Large amounts of riprap have been placed along roads paralleling the Grande Ronde River. These roads include Asotin County Road 100, Schumaker Road, and Snake River Road. Stability created by bank armoring in not desirable. Limited riparian vegetation, large cobble substrate, and high intensity flood events combine to create generally unstable banks (Mendel 2001, personal communication, Johnson 2001, personal communication).

Floodplain Connectivity

Floodplains are small and relatively uncommon in the narrow valley bottom of the Grande Ronde River canyon. The river generally appears to have access to floodplains (Mendel 2001, personal communication). No dikes were noted during observations from Shumaker Road and Asotin County Road 100, but a few homes are located on the floodplain just upstream from the Washington State Route 129 crossing (Kuttel 2001b). Roads constrict the channel at some locations (TAG 2001, personal communication).

Width/Depth Ratio

Generally unstable banks caused by naturally sparse riparian vegetation, cattle grazing, bank armoring, and high intensity flood events have led to a wide and shallow stream channel (Mendel 2001, personal communication).

Substrate Embeddedness

The Grande Ronde carries very high fine sediment loads during storm events. Substrate embeddedness is suspected to be a problem. Large chunks of ice discussed under fish passage scour the stream bed during ice out events, potentially damaging incubating fall chinook eggs or juveniles (Mendel 2001, personal communication).

Large Woody Debris

Very little large woody debris was visible during observations along Schumaker Road and Asotin County Road 100 in October 2001. The sparse riparian vegetation suggests that this is likely a natural occurrence (Kuttel 2001b). However, logging and stream cleaning activities in the upper watershed within Oregon may have reduced LWD abundance from historic levels (Mendel 2001, personal communication).

Pool Frequency

No pool frequency information was located, but large pools are common (TAG 2001, personal communication).

Pool Quality

Pocket pools formed downstream from large basalt boulders were the most common pool feature observed along Schumaker Road and Asotin County Road 100 in October 2001. Several very large and deep pools were noted along Schumaker Road in areas where the channel was cutting into the basalt walls of the canyon (Kuttel 2001b).

Off-Channel Habitat

Off-channel habitat is uncommon, likely a natural condition caused by the infrequency of floodplains in the Grande Ronde River canyon. Side channels are present along gravel bars and islands. These areas provide off-channel rearing habitat during the summer months, but are within the main channel during high flow events (Mendel 2002a, personal communication).

Water Quality/Temperature

Limited water temperature data were located. Daily maximum water temperatures measured at RM 0.5 on the Grande Ronde mainstem frequently exceeded 70 F in July 1998, 1999, and 2000 (FishPro 2001). The wide channel and sparse riparian vegetation suggest that summer water temperatures likely get relatively high, but the high canyon walls provide some topographic shading (Kuttel 2001b). Northwest Power Planning Council (2001b) described summer water temperatures exceeding PACFISH and NMFS standards in the lower Grande Ronde River, but no specific temperature values or stream reaches were identified.

Water Quantity/Dewatering

The Grande Ronde carried considerable flow in mid-October 2001, a drought year (Kuttel 2001b). Flows generally get very low during the summer and early fall months. This is partly a result of the climate, but irrigation diversions in the upper watershed within Oregon remove a substantial amount of flow (Northwest Power Planning Council 2001b). Permits, claims, and certificates on file with the Washington Department of Ecology (WDOE) identify a potential instantaneous withdrawal of 3 cfs of flow or 1,181 acre-feet per year of water from the Grande Ronde River (Neve 2001, personal communication).

Change in Flow Regime

Irrigation withdrawals in the Oregon portion of the Grande Ronde Watershed substantially reduce flows downstream in Washington (Mendel 2001, personal communication).

Biological Processes

Smallmouth bass are present in the lower Grande Ronde River. All anadromous fish runs in the Grande Ronde River system exhibit depressed returns. Coho were extirpated by 1985 (Northwest Power Planning Council 2001b).

Grande Ronde River Fish-Bearing Tributaries (within Washington): Joseph, Schumaker, Deer, Buford, Rattlesnake, Cottonwood, Bear, Cougar, Menatchee, and Grouse Creeks

Habitat Ratings

Fish Passage

A falls near RM 1.5 on Menatchee Creek is a barrier. The culvert under State Route 129 at Rattlesnake Creek may be a barrier. Several culverts on lower Grouse Creek may be partial barriers. With the exception of Joseph Creek, steep gradients (up to 12%) typically limit anadromy to the lower few miles of some of these streams. Juvenile rainbow/steelhead have been observed in the high gradient reaches. These fish are likely resident rainbow/redband trout, but they cannot be distinguished from steelhead (Mendel 2001, personal communication).

Screens and Diversions

Washington Department of Fish and Wildlife irrigates whitetail deer winter range along Joseph Creek. The pump diversion is screened to year 2001 state and federal regulations (Martin 2002, personal communication). There are likely more diversions in use (TAG 2002, personal communication).

Riparian Condition

Joseph Creek from the mouth upstream to the end of the Joseph Wildlife Area is dominated by a relatively narrow buffer of deciduous trees about 20 to 30 feet in height. Riparian vegetation along Schumaker Creek is generally shrubs with a few scattered pines in the upper reaches. Deciduous trees become dominant along the lower mile of Schumaker creek, but the buffer is very patchy. The upper reaches of Rattlesnake Creek are dominated by coniferous trees in the bottom of a steep canyon. A narrow but nearly continuous buffer of immature alder trees dominates riparian vegetation from the mouth of Rattlesnake Creek upstream to the Washington State Route 129 stream crossing (Kuttel 2001b). Deciduous trees in a relatively contiguous buffer dominate riparian vegetation along the majority of Cottonwood Creek. Riparian buffers along Grouse, Cougar, and lower Menatchee Creeks are generally in marginal condition. Cattle grazing near the mouth of Menatchee Creek has caused riparian degradation (Mendel 2001, personal communication).

Streambank Condition

Banks were generally stable on the USFS portion of Menatchee Creek when surveyed in 1993 (Forest Service 1993h, unpublished work). Streambanks along the lower portion of Schumaker Creek have been impacted by cattle grazing and high intensity storm events (Johnson 2001, personal communication). The high gradients of these streams, with the exception of lower Joseph Creek, leads to debris torrents during thunderstorms and rain-on-snow events (Mendel 2001, personal communication). Naturally sparse riparian vegetation, cattle grazing, high gradients, and frequent storm events lead to naturally unstable streambanks and formation of alluvial fans on the lower portions of these streams.

Floodplain Connectivity

These streams have very steep gradients, with the exception of lower Joseph Creek (Kuttel 2001b). They would be classified as “Aa+” or “A” streams under the Rosgen stream classification system (Rosgen 1996). Floodplains would not be expected to occur (See Figure 15).

Figure 15. Schumaker Creek Canyon demonstrating steep gradient. Photographed October 16, 2001.

Width/Depth Ratio

The average width/depth ratio of Menatchee Creek (1993) was 10.6 on USFS lands (Forest Service 1998, unpublished work). Data from summer 1986 WDFW stream surveys were used to calculate the following width/depth ratios: Menatchee Creek (31.8), Cottonwood Creek (21.3), and Rattlesnake Creek (38.0) (Schuck *et al.* 1988).

Substrate Embeddedness

Embeddedness was not a problem on Menatchee Creek (1993) with an average value of only 8.4% on 5.5 miles of stream surveyed on USFS lands (Forest Service 1998, unpublished work). No information was available for other tributaries or Menatchee Creek on private lands.

Large Woody Debris

Large wood was relatively plentiful on Menatchee Creek in 1993 with an average of 40 pieces per mile reported on USFS lands. Most LWD was concentrated in debris jams caught at narrow spots in the canyon (Forest Service 1993h, unpublished work). No information was available for other tributaries or Menatchee Creek on private lands.

Pool Frequency

An average of 12.5 pools per mile was reported for Menatchee Creek on USFS lands in 1993 (Forest Service 1998, unpublished work). No information was available for other tributaries or Menatchee Creek on private lands.

Pool Quality

Pools on the USFS portion of Menatchee Creek were large, occupying an average of 43% of stream surface area. Turbulence, pocket pools, and rocks provided “good to excellent” fish cover on Menatchee Creek (Forest Service 1993h, unpublished work). No information was available for other tributaries or Menatchee Creek on private lands.

Off-Channel Habitat

Side channels comprised an average of 5.25% of stream surface area on the USFS portion of Menatchee Creek when surveyed in 1993 (Forest Service 1993h, unpublished work). No information was available for other tributaries or Menatchee Creek on private lands.

Water Quality/Temperature

Average seven-day summer maximum water temperature on Menatchee Creek from the USFS boundary to the mouth was 64°F from 1992 to 2000 (Forest Service (USDA) 2001, unpublished work). High summer water temperatures limit salmonid use of lower Joseph Creek (Northwest Power Planning Council 2001b). No information was available for other tributaries or Menatchee Creek on private lands.

Water Quantity/Dewatering

WDFW measured the following flows in August 1986: Menatchee Creek (11.5 cfs), Cougar Creek (0.1 cfs), Rattlesnake Creek (0.2 cfs), Cottonwood Creek (1.0 cfs) (Schuck *et al.* 1988). Indian Tom Creek and Ranger Creek contribute about 20% and 10% of summer flows to Menatchee Creek respectively (Forest Service 1993h, unpublished work). The summer of 2001 was extremely dry. Schumaker Creek was dry when observed on October 16, 2001 (Kuttel 2001b). This stream is naturally intermittent (Johnson 2001, personal communication). Rattlesnake, Cottonwood, and Menatchee Creeks were all flowing when observed on the same date. Joseph Creek carried substantial flow as well (Kuttel 2001b).

Change in Flow Regime

Natural flow regimes are presumed to be present on these streams (TAG 2001, personal communication).

Biological Processes

Reduced levels of marine-derived nutrients contributed by anadromous fish (i.e. eggs, juveniles, and decomposing carcasses) likely limit productivity (Mendel 2002a, personal communication).

Wenaha River Fish-Bearing Tributaries (within Washington): Crooked, Butte, and Beaver Creeks, and North Fork Wenaha River

Habitat Ratings

These streams flow through the Wenaha-Tucannon Wilderness Area, a rugged roadless area. Access is limited to trails traveled by foot or on horseback. No logging has occurred since 1978 when the Wilderness Area was designated. Prior to this date, motorcycles were frequently used to travel the area. Cattle and sheep grazing of the area began in the 1880s and ended in 1992 (Forest Service 1993b, unpublished work). Limited prescribed burning is the primary management tool available for use in the Wilderness Area (Groat 2001, personal communication). Unless specifically discussed below, habitat forming processes and biological functions are presumed to be functioning naturally.

Fish Passage

A 30' high falls at RM 2.8 (near the mouth of Preacher Creek) on West Fork Butte Creek is a natural barrier (Forest Service 1995c, unpublished work). No barriers were identified on Crooked Creek from the mouth to RM 9.2 (Forest Service 1993b, unpublished work). Two logjams on First Creek between the mouth and the forks (RM 4.5) may have been barriers when surveyed in 1994 (Forest Service 1994b, unpublished work). No barriers were noted on East Fork First Creek from the mouth to RM 2.6 (Forest Service 1994a, unpublished work). No barriers were observed on Melton Creek from the mouth upstream to RM 1.9 in 1994 (Forest Service 1994d, unpublished work). No barriers were observed on Third Creek from the mouth upstream to Trout Creek (RM 3.2) when surveyed in 1994 (Forest Service 1994g, unpublished work). No barriers were noted on the North Fork Wenaha River from the mouth to RM 3.7 when surveyed in 1994 (Forest Service 1994e, unpublished work).

Screens and Diversions

No irrigation diversions are present (TAG 2001, personal communication).

Riparian Condition

Coniferous trees generally dominate vegetation in the Wilderness Area. Mature and second growth Douglas-fir and grand fir dominated the riparian overstory along First Creek, East Fork First Creek, Second Creek, Third Creek, and the North Fork Wenaha River. Alder was the dominant understory vegetation (Forest Service 1994a, unpublished work, Forest Service 1994b, unpublished work, Forest Service 1994e, unpublished work, Forest Service 1994f, unpublished work, Forest Service 1994g, unpublished work). Shading averaged 24% on East Fork First Creek (Forest Service 1994a, unpublished work). Canopy closure along Second Creek was greater than 60% (Forest Service 1994f, unpublished work). Canopy closure on Melton Creek ranged from 30 to 60% in 1994 (Forest Service 1994d, unpublished work). With the exception of fire suppression practices, natural processes are presumed to be maintained (TAG 2001, personal communication). Alder and Douglas-fir dominate riparian vegetation along Butte Creek (Forest Service 1995a, unpublished work). Young alder and Douglas-fir dominated the riparian zone of East and West Fork Butte Creek when surveyed in 1995. Canopy closure from the mouth to RM 1.8 on East Fork Butte Creek was 31 to 60% in 1995. No logging, mining, or road building have ever occurred in the East and West Fork Butte Creek Watersheds (Forest Service 1995b, unpublished work, Forest Service 1995c, unpublished work).

Streambank Condition

Bank cover along First Creek ranged from 76 to 100% (Forest Service 1994b, unpublished work). Bank stability was "excellent" along East Fork First Creek (Forest Service 1994a, unpublished work). Banks along Melton Creek and Second Creek were generally stable (Forest Service 1994d, unpublished work, Forest Service 1994f, unpublished work). Third Creek had stable banks throughout the 3.2 miles surveyed (Forest Service 1994g, unpublished work). The majority of banks along the lower 3.7 miles of the North Fork Wenaha River were stable in 1994 (Forest Service 1994e, unpublished work). Banks from the mouth of Butte Creek to RM 6.9 were stable in 1995 (Forest Service 1995a, unpublished work). Bank cover from the mouth to RM 2.7 on West Fork Butte Creek was 76 to 100% in 1995 (Forest Service 1995c, unpublished work). Banks along East Fork Butte Creek were generally stable when surveyed in 1995 (Forest Service 1995b, unpublished work).

Floodplain Connectivity

These streams drain extremely steep canyons. Floodplains would likely be small or nonexistent (TAG 2001, personal communication).

Width/Depth Ratio

Data from summer 1986 WDFW stream surveys were used to calculate a width/depth ratio of 44.7 on Crooked Creek (Schuck *et al.* 1988). In 1995, width/depth ratio on Butte Creek averaged 10.4, while it was 9.7 on East Fork Butte Creek and 21.1 on West Fork Butte Creek. The average ratio on Crooked Creek (1993) was 17.4. 1994 surveys of Second, and Third Creeks revealed width/depth ratios of 8.9, and 11.8 respectively (Forest Service 1998, unpublished work). The width/depth ratios of First Creek and East Fork First Creek averaged 10.5 and 6.7 respectively in 1994 (Forest Service 1994a, unpublished work, Forest Service 1994b, unpublished work). The width/depth ratio of Melton Creek in 1994 was 4.9 (Forest Service 1994d, unpublished work). The North Fork Wenaha River had an average width/depth ratio of 17 in 1994 (Forest Service 1998, unpublished work).

Substrate Embeddedness

Average embeddedness on Butte Creek, East Fork Butte Creek, and West Fork Butte Creek in 1995 were 23%, 25% and 25% respectively. Values on Crooked Creek (1995), First Creek, East Fork First Creek, and Second Creek (1994) averaged 24.5%, 11.3%, 27%, and 24% respectively (Forest Service 1998, unpublished work). Substrate on Second Creek had 24% embeddedness (Forest Service 1994f, unpublished work). Embeddedness on Third Creek was 19.5% (Forest Service 1994g, unpublished work). Average embeddedness on the North Fork Wenaha River in 1994 was 16% (Forest Service 1994e, unpublished work). Embeddedness on Melton Creek (1994) was 20% (Forest Service 1994d, unpublished work).

Large Woody Debris

Large wood was relatively common on all streams in the Washington portion of the Wenaha system when surveyed from 1993 to 1995. Butte and East Fork Butte Creeks both had average values of 37 pieces per mile, while West Fork Butte Creek had an average of 20 pieces per mile. Values on Crooked Creek, First Creek, East Fork First Creek, Second Creek, and Third Creek averaged 20, 47, 51, 32, and 19 pieces per mile respectively. The North Fork Wenaha River averaged 32 pieces per mile (Forest Service 1998, unpublished work). Large woody debris pieces per mile on Melton Creek was 63 (Forest Service 1994d, unpublished work).

Pool Frequency

Average pools per mile on Butte, East Fork Butte, and West Fork Butte Creeks in 1995 was 9 (7.5% stream surface area), 6, and 2 respectively. Pools were not common on Crooked, First, East Fork First, and Second Creeks with average values of 4, 10.5, 6, and 1 pools per mile respectively (Forest Service 1995a, unpublished work, Forest Service 1998, unpublished work). Third Creek had 3 pools per mile (1.1% stream surface area) (Forest Service 1994g, unpublished work). The North Fork Wenaha River averaged 7 pools per mile (3.8% stream surface area) in 1994 (Forest Service 1994e, unpublished work). Melton Creek had 6 pools per mile (1.7% stream surface area) when surveyed in 1994 (Forest Service 1994d, unpublished work). The low pool frequencies are the natural condition for these wilderness streams (TAG 2002, personal communication).

Pool Quality

Residual pool depth on Crooked Creek averaged 2.7 feet when surveyed in 1993 (Forest Service 1993b, unpublished work). Large woody debris and spaces between boulders and cobbles provided "good" instream fish cover on First Creek in 1994 (Forest Service 1994b, unpublished work). Overhanging vegetation and spaces between cobbles provided "good to excellent" instream cover on East Fork First Creek (Forest Service 1994a, unpublished work). Overhanging vegetation and LWD provided abundant fish cover in Melton Creek (Forest Service 1994d, unpublished work). Turbulence, overhanging vegetation and spaces between rocks provided "good" fish cover on Third Creek (Forest Service 1994g, unpublished work). Average pool depth on Butte Creek was 3.6 feet in 1995 (Forest Service 1995a, unpublished work). Mean pool depth was 2.6 feet on West Fork Butte Creek and 2.8 feet on East Fork Butte Creek (Forest Service 1995b, unpublished work, Forest Service 1995c, unpublished work). Instream habitat on West Fork Butte Creek was characterized as "good" (Forest Service 1995c, unpublished work).

Off-Channel Habitat

Off-channel habitat is likely not present because of the steep gradients of these streams (TAG 2001, personal communication).

Water Quality/Temperature

Average summer seven-day maximum water temperatures (1994 to 2000) at the mouths of Butte and Crooked Creeks were 66 °F and 70 °F respectively (Forest Service (USDA) 2001, unpublished work). The elevated temperatures are largely a result of the north-south aspect of the lower portions of the two streams, which limits topographic shading. Temperatures are lower in other portions of the watershed (Groat 2001, personal communication).

Water Quantity/Dewatering

WDFW measured the following flows in September 1986: Crooked Creek near First Creek (11.4 cfs), First Creek at USFS cabin (5.7 cfs), N.F. Wenaha River near mouth (53.4 cfs) (Schuck *et al.* 1988). Flow at the mouth of Melton Creek was estimated at 9 cfs in early July 1994 (Forest Service 1994d, unpublished work). Flow at the mouth of Third Creek was estimated at 13 cfs in mid-July 1994 (Forest Service 1994g, unpublished work). The North Fork Wenaha River carried an estimated 30 cfs of flow when observed in August 1994 (Forest Service 1994e, unpublished work). Flow was estimated at 57 cfs at the mouth of Butte Creek in June 1995 (Forest Service 1995a, unpublished work).

Change in Flow Regime

No surface water diversions are present. No land management activities such a logging or grazing are allowed. The flow regime is presumed to be functioning naturally (TAG 2001, personal communication).

Biological Processes

Reduced levels of marine-derived nutrients contributed by anadromous fish (i.e. eggs, juveniles, and decomposing carcasses) likely limit productivity (Mendel 2002a, personal communication).

GRANDE RONDE SUBBASIN RECOMMENDATIONS

Continue to protect high quality salmonid habitat within the Wenaha-Tucannon Wilderness Area.

Practice proper riparian vegetation management to ensure healthy vigorous plant growth of woody vegetation and natural regeneration. Best management practices (BMPs) could include, but are not limited to: limited riparian "flash grazing," pasture rotation, fencing livestock out of streams and riparian areas, and development of off-site watering facilities.

In the short term, improve instream habitat through placement of large woody debris and pool construction in very specific and limited areas identified by technical experts. Reliance on instream projects should be minimized since they largely treat symptoms, rather than addressing the root cause(s) of habitat degradation.

Continue to reduce fine sediment inputs to the Grande Ronde River through implementation of no-till/direct seed farming methods, CRP, CREP, and other BMPs.

Inventory habitat conditions as well as fish presence and relative abundance on the Grande Ronde mainstem and tributaries within Washington every five years to fill data gaps and monitor success of habitat restoration projects. Conduct continuous monitoring of water quality parameters such as water temperature and total suspended solids.

Evaluate culverts on the lower end of Grouse Creek and replace if they block fish passage.

Enforce existing land use regulations including Critical Area Ordinances, Shoreline Management Act, and the Growth Management Act.

Reduce or control encroachment of roads and rural development along stream channels and riparian areas.

TENMILE-COUSE SUBBASIN HABITAT LIMITING FACTORS

Tenmile-Couse Subbasin Description

The Tenmile-Couse Subbasin encompasses the Tenmile (approximately 42 sq. miles) and Couse Creek (approximately 26 sq. miles) watersheds and all tributaries. The streams originate in the foothills of the northeast portion of the Blue Mountains. Tenmile Creek begins at about 3,940 feet elevation at the headwaters of Mill Creek, while Couse Creek originates at about 3,610 feet elevation. Tenmile and Couse Creeks enter the Snake River at (RM 150 at about 1,100 feet in elevation) and (RM 158 at 1,200 feet in elevation) respectively (DeLorme Mapping 1995) (See Map 12). Dryland agriculture is the dominant land use on ridge tops, while grazing dominates the steep canyon slopes. The subbasin is characterized by deep v-shaped valleys. The topography is the result of folding and faulting of extensive deposits of Columbia River Basalts. Highly erodible loess soils on the plateau tops support extensive acreages of dryland farming. Considerable acreages of cropland are enrolled in CRP (2,300 acres Couse Creek, 3,500 acres Tenmile Creek) (Johnson 2001, personal communication). There is generally a large difference in elevation between the valley bottom and the surrounding plateaus. Intermittent and/or ephemeral streams are present throughout the watershed. Under typical conditions these streams do not convey much water, but during thunderstorms or rain-on–snow events they are capable of carrying immense debris torrents. The sediment moving capacity of these small streams is easily seen in the extensive alluvial fans deposited at their mouths. Habitat conditions in the Tenmile-Couse Subbasin are generally poor to fair (See Table 10).

Summer steelhead/resident rainbow trout, are present in both Tenmile and Couse Creeks and Mill Creek (tributary of Tenmile Creek) (See Appendix B).

Couse Creek

<u>Habitat Ratings</u>

<u>Fish Passage</u>

Low flows caused by evaporation and/or subsurface flows restrict migration of juvenile salmonids throughout the system and in drought conditions block or delay adult salmonid migration into Couse Creek (Mendel 2001, personal communication, Johnson 2001, personal communication). Two barriers, one an impassable logjam, were identified on Couse Creek from RM 0.1 to RM 1.6. Five barriers, generally steep gradients were noted from RM 1.6 to RM 3.1 (Mendel 2001, unpublished work).

<u>Screens and Diversions</u>

No surface water diversions are present on Couse Creek (Johnson 2001, personal communication).

<u>Riparian Condition</u>

Grasses, sedges, rushes, shrubs, and deciduous trees were the primary riparian vegetation along Couse Creek from RM 0.1 to RM 1.6. The buffer averaged 29’ in width with a mean height of 7’ and an average maximum height of 31’. Shading averaged on 5%. (Mendel 2001, unpublished work) (See Figure 16). From this point upstream to the bridge at Montgomery

Gulch (RM 3.1) the riparian buffer was nearly nonexistent. Forbs, grasses, sedges, and rushes were the dominant plants. Shading averaged only 10% (Mendel 2001, unpublished work). The damage was likely caused by the 1996-97 floods. A patchy buffer of scattered trees and shrubs is present from Montgomery Gulch upstream (Mendel 2001, personal communication, Mendel *et al.* 2001).

Figure 16. Riparian buffer on Couse Creek downstream from RM 1.6. Photographed October 2001.

Streambank Condition

Streambanks on the lower portion of stream (up to RM 1.6) were stable while banks upstream with degraded riparian vegetation were generally unstable (Mendel *et al.* 2001). Banks from RM 0.1 to RM 1.6 showed moderate damage from livestock grazing. An average of 30% of banks were eroding (Mendel 2001, unpublished work). Banks were severely damaged from RM 1.6 to RM 3.1. Moderate damage from livestock grazing was noted (Mendel 2001, unpublished work), but floods likely caused the majority of bank damage (Johnson 2001, personal communication). An average of 44% of banks were eroding (Mendel 2001, unpublished work). Grazing in the riparian zone appears to maintain the degraded channel conditions (Mendel 2001, personal communication).

Floodplain Connectivity

The floodplain along Couse Creek is naturally small because of the relatively narrow valley bottom. Couse Creek Road limits floodplain connectivity to a small degree, but in general the stream has access to the floodplain (Mendel 2001, personal communication).

Width/Depth Ratio

The width/depth ratio from RM 0.1 to RM 1.6 was 8.3 and 20 from RM 1.6 to RM 3.1 (Mendel 2001, unpublished work).

Substrate Embeddedness

Fine sediment was common throughout Couse Creek during 2000 stream surveys(Mendel *et al.* 2001). A layer of fine sediment covered all rock surfaces and was easily disturbed when wading during stream surveys. Surveyors had to work in an upstream direction to maintain visibility in the water column (Mendel 2001, personal communication). Cobble and boulders were the dominant substrate from RM 0.1 to RM 1.6. Embeddedness was generally 25 to 50%. Cobble was the dominant substrate from RM 1.6 to RM 3.1. Embeddedness was generally <25% (Mendel 2001, unpublished work).

Large Woody Debris

Large woody debris was present in areas where woody riparian vegetation could entrap debris (Mendel *et al.* 2001, Mendel 2001, unpublished work), but it was essentially non existent in areas of degraded riparian vegetation (Mendel 2001, personal communication).

Pool Frequency

Pool frequency was 14 per mile from RM 0.1 to RM 1.6 (Mendel 2001, unpublished work).

Pool Quality

Couse Creek was characterized by riffles and small plunge and lateral scour pools (Mendel *et al.* 2001). Some large pools with cover were present, but not plentiful (Mendel 2001, unpublished work).

Off-Channel Habitat

Off-channel habitat is very limited on Couse Creek (Mendel 2001, personal communication).

Water Quality/Temperature

Maximum water temperatures frequently exceeded 70 °F during July and August 2000 on upper Couse Creek, but only occasionally reached 70 °F near the mouth. Conversely average temperatures for this time period at the upper site rarely reached 65 °F, while the lower site routinely exceeded 65 °F (Mendel *et al.* 2001). Mean water temperatures at RM 0.1 frequently exceeded 65 °F in July and August 2001. Daily maximum temperatures frequently approached 70 °F (Mendel 2001, unpublished work). Turbidity gets very high at times (Mendel 2001, personal communication).

Water Quantity/Dewatering

In July 2000, Couse Creek was dry from about 1.5 miles above the mouth to 0.5 miles above the bridge at Montgomery Gulch. However, juvenile steelhead/rainbow trout were found in isolated pools. Flows measured 0.2 miles above the mouth were 3.63 cfs, 1.59 cfs, and 0.93 cfs on April 13, July 26, and October 13, 2000 respectively (Mendel *et al.* 2001). Flow measured at RM 0.1 was 1.84 cfs on April 3, 2001; 2.39 cfs on April 18, 2001; 0.75 cfs on July 12, 2001, and 0.95 cfs on November 9, 2001 (Mendel 2001, unpublished work).

Change in Flow Regime

The natural flow regime is presumed to be present (TAG 2001, personal communication).

Biological Processes

Reduced levels of marine-derived nutrients contributed by anadromous fish (i.e. eggs, juveniles, and decomposing carcasses) likely limit productivity (Mendel 2002a, personal communication).

Tenmile Creek (Headwaters to Mill Creek)

Habitat Ratings

Fish Passage

A man made dam and pond built in 1997-98 on Tenmile Creek near the line between T8N R 45 E Sec 36 and T8N R 46E Sec 31 is a barrier (Mendel 2001, personal communication). Several culverts on Mill Creek in the town of Anatone may be barriers (Mendel *et al.* 2001).

Screens and Diversions

A concrete diversion structure on Mill Creek at Anatone is unscreened (Mendel 2001, personal communication, Mendel *et al.* 2001).

Riparian Condition

Hawthorn, cottonwood, willows, and conifers are present along this portion of Tenmile Creek. Buffer condition ranges from functional to degraded. Tall grass and an occasional hawthorn were the primary riparian vegetation along Mill Creek near Anatone. The hawthorn stand becomes particularly dense from one mile downstream of Anatone to 1.5 miles downstream. From this point downstream to the mouth hawthorns, tall grass, and an occasional conifer vegetate the riparian zone (Mendel *et al.* 2001).

Streambank Condition

This reach of Tenmile Creek is primarily braided channel with eroding banks (Mendel 2001, personal communication). Bank stability on Mill Creek ranged from actively eroding to moderately stable (Mendel *et al.* 2001).

Floodplain Connectivity

Floodplains on this reach are naturally small. No dikes or roads impede floodplain connectivity (Mendel 2001, personal communication).

Width/Depth Ratio

The stream is moderately wide in areas with woody riparian vegetation, but overly wide and shallow in the braided reaches associated with degraded riparian buffers (Mendel 2001, personal communication).

Substrate Embeddedness

Fine sediment levels were moderate throughout Tenmile Creek. Mill Creek had moderate to heavy fine sediment levels with high turbidity noted during WDFW surveys (Mendel *et al.* 2001). A layer of fine sediment covered all rock surfaces and reduced visibility during stream surveys (Mendel 2001, personal communication).

Large Woody Debris

Small amounts of LWD were present in reaches with some woody riparian vegetation. LWD was absent in areas with little or no woody riparian vegetation (Mendel 2001, personal communication).

Pool Frequency

No information on pool frequency was available.

Pool Quality

Channel morphology of this reach of Tenmile Creek is characterized by small riffles with plunge and lateral scour pools. The gradient of Mill Creek is steep with small riffles and plunge pools (Mendel *et al.* 2001).

Off-Channel Habitat

Little or no off-channel habitat is present (Mendel 2001, personal communication).

Water Quality/Temperature

Maximum water temperatures from June through the end of July 2000 frequently exceeded 75 °F on this reach of Tenmile Creek. However, the average water temperature during this time period rarely exceeded 65 °F. Maximum water temperatures on Mill Creek for June 2000 rarely exceed 70 °F and average temperatures through late July 2000 were always below 65 °F. Monitoring on Mill Creek stopped after late July because the stream went dry (Mendel *et al.* 2001).

Water Quantity/Dewatering

Portions of Mill Creek went dry during the summer of 2000 (Mendel *et al.* 2001).

Change in Flow Regime

The pond on upper Tenmile Creek may dampen flood peaks downstream (Mendel 2001, personal communication).

Biological Processes

Reduced levels of marine-derived nutrients contributed by anadromous fish (i.e. eggs, juveniles, and decomposing carcasses) likely limit productivity (Mendel 2002a, personal communication).

Tenmile Creek (Mill Creek to Mouth)

Habitat Ratings

Fish Passage

Portions of the channel from RM 2 upstream go dry during the summer and early fall delaying and/or blocking adult steelhead migration and stranding both adults and juveniles in isolated pools (Mendel 2001, personal communication). No physical barriers were identified from RM 0.1 to RM 6.1 (Mendel 2001, unpublished work).

Screens and Diversions

No diversions were observed from RM 0.1 to RM 6.1 (Mendel 2001, unpublished work).

Riparian Condition

Riparian vegetation along this reach ranged from partial stands to no vegetation in areas of severe scour and flood deposition (Mendel *et al.* 2001). The lower 1.5 to 2 miles of stream have a relatively dense riparian buffer in some areas, but portions have been damaged by cattle grazing. Winter confinement areas limit the width of the riparian buffer in some areas (Mendel 2001, personal communication). From RM 0.1 to RM 0.7, grasses, sedges, and rushes were the primary plants in the riparian understory. Deciduous trees dominated the overstory. Mean riparian height was 16' with an average maximum of 32'. The buffer was an average of only 5' wide and provided an average of 22% shading. Riparian plant species were the same as above (with some grazed pasture) from RM 0.7 to RM 1.2. The buffer averaged 5' in width, and was generally not as tall with a mean height of 12.5' and maximum height of 25', but it provided an average of 30% shade. The riparian buffer from RM 1.2 to RM 3.7 was nearly identical to that of RM 0.7 to RM 1.2, but it had an average width of 16.5'. A buffer averaging 30' wide composed of the previous plant species was found from RM 3.7 to RM 6.1. This buffer provided 26% shading (Mendel 2001, unpublished work).

Streambank Condition

Banks showed moderate damage from RM 0.1 to RM 0.7. Livestock grazing has caused some of the damage. An average of 33% of banks were actively eroding. From RM 0.7 to RM 1.2 bank stability ranged from moderately stable to unstable. Livestock grazing contributed to severe bank damage on the unstable portions. Banks from RM 1.2 to RM 3.7 were moderately stable with little evidence of livestock damage. An average of 33% of banks were eroding. Banks were often oversteepened or cut and actively eroding from RM 3.7 to RM 6.1. Livestock damage was noted throughout this reach, but was not the only cause for bank failure (Mendel 2001, unpublished work).

Floodplain Connectivity

Cobble berms and a high bank restricted access to the floodplain from RM 0.1 to RM 0.7. Portions of the channel had access to a floodplain from RM 0.7 to RM 1.2. The floodplain is accessible from RM 1.2 to RM 3.7. Portions of the reach from RM 3.7 to RM 6.1 had access to a floodplain (Mendel 2001, unpublished work). Channel incision and basalt canyon walls naturally limit floodplain connectivity (Mendel 2001, personal communication).

Width/Depth Ratio

Tenmile Creek had a width/depth ratio of 42.5 from RM 0.1 to RM 0.7. Conditions improved upstream with a ratio of 17 from RM 0.7 to RM 1.2. The width/depth ratio was 13 from RM 1.2 to RM 3.7 and 24 from RM 3.7 to RM 6.1 (Mendel 2001, unpublished work).

Substrate Embeddedness

Fine sediment levels were moderate throughout Tenmile Creek during 2000 WDFW surveys (Mendel *et al.* 2001). Cobble was the primary substrate from RM 0.1 to RM 3.7. Embeddedness was generally <25%. Embeddedness increased to 25 to 50% from RM 3.7 to RM 6.1 (Mendel 2001, unpublished work).

Large Woody Debris

Woody debris was rare or non-existent from RM 0.1 to RM 6.1 (Mendel 2001, unpublished work).

Pool Frequency

Tenmile Creek had 8.3 pools per mile from RM 0.1 upstream to RM 0.7. Pools were slightly more numerous upstream with 10 per mile from RM 0.7 to RM 1.2. Pools per mile were 7.6 from RM 1.2 to RM 3.7 and 12.5 per mile from RM 3.7 to RM 6.1 (Mendel 2001, unpublished work).

Pool Quality

Riffles and runs dominated this reach. Pools were generally small with little or minimal cover. Turbulence was the dominant instream cover. Some large pools with cover were present from RM 3.7 to RM 6.1 (Mendel 2001, unpublished work).

Off-Channel Habitat

Little or no off-channel habitat is present on this reach of Tenmile Creek (Mendel 2001, personal communication). No off-channel habitat was present from RM 0.7 to RM 1.2. Some side channel habitat was present from RM 1.2 to RM 3.7. No off-channel habitat was present from RM 3.7 to RM 6.1 (Mendel 2001, unpublished work).

Water Quality/Temperature

Maximum water temperatures during June and July 2000 frequently exceeded 70 °F and occasionally exceeded 75 °F. Average water temperatures exceeded 65 °F for a few days in June and about two weeks in July (Mendel *et al.* 2001). Mean water temperatures at RM 0.1 frequently exceeded 65 °F from mid-June through mid-August 2001. Daily maximum temperatures often exceeded 70 °F during the same time period. Conditions improved upstream at RM 6.1 where mean water temperatures exceeded 60 °F only a few days from July through mid-August 2001 and daily maximum temperatures rarely exceeded 65 °F (Mendel 2001, unpublished work).

Water Quantity/Dewatering

Flow measured at the Snake River Road Bridge was 10.6 cfs on April 13, 2000 (Mendel *et al.* 2001), but flows were substantially lower in July and August 2000 (Mendel 2001, personal communication). Flow at the Snake River Road Bridge was 5.34 cfs on April 3, 2001, 0.72 cfs on July 12, 2001, and 0.86 cfs on November 9, 2001. Flow at RM 1.4 was 3.38 cfs on April 23, 2001 (Mendel 2001, unpublished work). Portions of the stream go dry from RM 2 upstream leaving fish stranded in isolated pools during the summer months (Mendel 2001, personal communication).

Change in Flow Regime

The pond on upper Tenmile Creek may dampen flood peaks downstream (Mendel 2001, personal communication).

Biological Processes

Reduced levels of marine-derived nutrients contributed by anadromous fish (i.e. eggs, juveniles, and decomposing carcasses) likely limit productivity (Mendel 2002a, personal communication).

TENMILE-COUSE SUBBASIN RECOMMENDATIONS

Continue reduction of fine sediment loads to Tenmile and Couse Creeks through no-till/direct seed farming methods, CRP, CREP, and other BMPs.

Restore riparian forest buffers on both streams, particularly from about RM 2 upstream.

Practice proper riparian vegetation management to ensure healthy vigorous plant growth of woody vegetation and natural regeneration. Best management practices (BMPs) could include, but are not limited to: limited riparian "flash grazing," pasture rotation, fencing livestock out of streams and riparian areas, and development of off-site watering facilities.

Inventory habitat conditions as well as fish presence and relative abundance on Tenmile and Couse Creeks every five years to fill data gaps and monitor success of habitat restoration projects. Conduct continuous monitoring of water quality parameters such as water temperature and total suspended solids.

Evaluate a channel and riparian restoration project on Couse Creek from about RM 2 upstream to the bridge at Montgomery Gulch.

Instream habitat projects should be limited because of the "flashy" nature of both streams.

In the long term, reduce summer stream temperatures through riparian buffer restoration.

Enforce existing land use regulations including Critical Area Ordinances, Shoreline Management Act, and the Growth Management Act.

Reduce and/or minimize stream encroachment and erosion from valley bottom roads.

ASOTIN SUBBASIN HABITAT LIMITING FACTORS

Asotin Subbasin Description

The Asotin Subbasin encompasses the entire Asotin Creek watershed and all tributaries (approximately 326 square miles). The stream system originates high in the northeast portion of the Blue Mountains at an elevation of 6,200 feet and terminates at the Snake River (RM 145) at about 800 feet elevation (See Map 13). Dryland agriculture and livestock grazing are the dominant land uses in mid-elevation upland areas, while forestry and grazing are the dominant land uses at higher elevations. Winter confined animal feeding operations (CAFOs) are located along many stream reaches (Asotin County Conservation District 1995). The city of Asotin (population 1,095) is the only town in the subbasin (Census Bureau 2001b). The subbasin is characterized by deep v-shaped valleys in headwater areas gradually widening into comparatively broad valley bottoms on the lower mainstem of Asotin Creek. The topography is the result of folding and faulting of extensive deposits of Columbia River Basalts. Highly erodible loess soils on the plateau tops support extensive acreages of dryland farming. Nearly 21,000 acres of cropland are currently enrolled in CRP (Johnson 2001, personal communication). There is generally a large difference in elevation between the valley bottom of Asotin Creek and the surrounding plateaus. Intermittent and/or ephemeral streams are present throughout the watershed. Under typical conditions these streams do not convey much water, but during thunderstorms or rain-on–snow events they are capable of carrying immense debris torrents into Asotin Creek. The sediment moving capacity of these small streams is easily seen in the extensive alluvial fans deposited at their mouths. Habitat conditions in the Asotin Subbasin vary considerably ranging from poor to good depending upon the location in the watershed (See Table 10).

Salmonid bearing streams in the subbasin include the North Fork of Asotin Creek, Cougar Creek, Middle Branch and South Fork of North Fork Asotin Creek, South Fork Asotin Creek, Lick Creek, Charley Creek, George Creek, Coombs Creek, Hefflefinger Creek, Wormell Creek, and Pintler Creek. Summer steelhead, resident rainbow trout, and bull trout are currently present in the subbasin. Spring chinook were historically present and are occasionally observed, but the indigenous population may be extinct (Mendel 2001, personal communication) (See Appendix B).

North Fork Asotin Creek (including tributaries)

Habitat Ratings

Fish Passage

No waterfalls, dams, or culverts were noted during 1992 USFS surveys of North Fork Asotin Creek or Cougar Creek (Forest Service 1992c, unpublished work, Forest Service 1992g, unpublished work). The upper reaches of South Fork of North Fork Asotin Creek have 12 waterfalls cascading over basalt layers. The nine uppermost falls may be barriers (Forest Service 1993f, unpublished work). No barriers were noted on Lick Creek from the USFS boundary upstream 5.6 miles (Forest Service 1994c, unpublished work). A culvert on lower Lick Creek may be a barrier (Mendel 2001, personal communication).

Screens and Diversions

No irrigation diversions are in use on these streams (TAG 2001, personal communication).

Riparian Condition

Grand fir, Ponderosa pine, and Douglas-fir were the dominant conifers on the floodplain of the North Fork of Asotin Creek, while alder was the dominant deciduous tree when surveyed in 1992. Canopy cover averaged 39%. (Forest Service 1992g, unpublished work). Grand fir and Douglas-fir dominated the riparian overstory along Cougar Creek, while alder and ninebark dominated the understory. Extensive logging took place along Cougar Creek with no buffer left in some cases. Grasses have taken over these clearcut areas with little evidence of conifer regeneration. Grazing had occurred, but was limited by steep slopes (average of 75%). Fire damage was also noted. A deep canyon at the mouth of the stream prevented logging of this portion of the riparian zone (Forest Service 1992c, unpublished work). Grand fir and Douglas-fir dominated the riparian zone of South Fork of North Fork Asotin Creek. Alder dominated the understory. Past clear cuts were logged to the edge of the stream. Grazing occurred along the lower end of the stream (Forest Service 1993f, unpublished work). Riparian vegetation along the Middle Branch of North Fork Asotin Creek was similar to the South Fork of North Fork Asotin Creek. Logging of steep slopes upstream from RM 2.5 has led to increased erosion (Forest Service 1993d, unpublished work). Riparian vegetation on Lick Creek from the USFS boundary upstream to Dry Lick Creek (2.8 river miles) was described as in "poor condition." Past clear cuts left no buffer along the stream. Conditions improved from Dry Lick Creek upstream an additional 2.8 miles where riparian vegetation was dominated by mature and second growth conifers and alder (Forest Service 1994c, unpublished work). State lands along these streams were salvage logged following the 1973 flood. In some cases live standing trees were cut to make the operation profitable. Deciduous revegetation has occurred, but coniferous plantings are needed (Mendel 2001, personal communication). The riparian zone along Lick Creek has been degraded by over grazing and fires (Asotin County Conservation District 1995). The entire Lick Creek Watershed is now in public ownership. Land management has shifted from resource extraction to protection/restoration (TAG 2001, personal communication).

Streambank Condition

Streambank cover ranged from 76 to 100% during 1992 USFS surveys of North Fork Asotin Creek (Forest Service 1992g, unpublished work). Large portions of Lick Creek on USFS lands show evidence of channel incision, while other areas of the channel have widened substantially (Forest Service 1994c, unpublished work).

Floodplain Connectivity

The floodplain along the USFS portion of North Fork Asotin Creek ranges from 20 to 400 feet in width with an average of 150 feet. The upper reaches of the stream are moderately entrenched, which is reasonable based on the relatively steep gradient (Forest Service 1992g, unpublished work). The floodplain width of Cougar Creek ranged from 15 to 60 feet. The average gradient of the stream was 4% in 1992 (Forest Service 1992c, unpublished work). Floodplains along South Fork of North Fork Asotin Creek and Middle Branch of North Fork Asotin Creek were described as "in very good condition" (Forest Service 1993d, unpublished work, Forest Service 1993f, unpublished work).

Width/Depth Ratio

Data from summer 1986 WDFW stream surveys were used to calculate a mean width/depth ratio of 26.6 on North Fork Asotin Creek (Schuck *et al.* 1988). In 1992, Cougar Creek had a width/depth ratio of 6.1 (Forest Service 1992c, unpublished work). The Middle Branch of North Fork Asotin Creek and South Fork of North Fork Asotin Creek were also relatively narrow and deep with ratios of 9.4 and 7.4 respectively in 1993 (Forest Service 1993d, unpublished work, Forest Service 1993f, unpublished work). Width/depth ratio on the USFS portion of North Fork Asotin Creek average 9 in 1992 (Forest Service 1992g, unpublished work). Lick Creek became much wider between 1994 and 1996 with average width/depth ratios of 5.3 and 13.4 respectively (Forest Service 1998, unpublished work).

Substrate Embeddedness

1992 embeddedness levels on Cougar Creek were >35%. Embeddedness became more severe as one progressed upstream to the riparian clear cuts discussed previously (Forest Service 1992c, unpublished work). This reach is above salmonid rearing habitat. Conditions have improved and bull trout redds have been observed (Groat 2001, personal communication). Embeddedness on the Middle Branch of North Fork Asotin Creek in 1993 averaged 27%. Conditions were slightly worse on the South Fork of North Fork Asotin Creek with an average of 31% embeddedness (Forest Service 1998, unpublished work). Clear cuts upstream from RM 5.25 have led to increased erosion and the associated substrate embeddedness (Forest Service 1993f, unpublished work). Embeddedness averaged 21% on the USFS portion of North Fork Asotin Creek during 1992 inventories. Although embeddedness levels on Lick Creek are high, some improvement occurred with 1994 levels at 47.5% and 1996 levels ranging from 25% to >35% (Forest Service 1998, unpublished work). Current conditions are similar (Groat 2001, personal communication). Substrate embeddedness was not observed on lands downstream from USFS lands during 1993 pebble counts, nor was it observed in the 2000 assessment (Natural Resources Conservation Service (USDA) 2001). North Fork Asotin Creek contributes about 10% of the fine sediment load of Asotin Creek (Asotin County Conservation District 1995).

Large Woody Debris

Cougar Creek had large amounts of LWD with 100 pieces per mile counted in 1992. In 1993, 88 pieces per mile of large wood were inventoried on the Middle Branch of North Fork Asotin Creek. Large wood was also abundant on the South Fork of North Fork Asotin Creek with 143 pieces per mile found in 1993. LWD levels on the USFS portion of North Fork Asotin Creek averaged 46 pieces per mile in 1992 (Forest Service 1992g, unpublished work). LWD levels on the USFS portion of Lick Creek improved substantially from 5 pieces per mile in 1994 to 48 pieces per mile in 1996 (Forest Service 1998, unpublished work).

Pool Frequency

In 1992, 14 pools per mile were counted on Cougar Creek. Pools per mile averaged 4.8 (1.4% stream surface area) on the Middle Branch of North Fork Asotin Creek (Forest Service 1993d, unpublished work) and 13.3 (2.5% stream surface area) on the South Fork of North Fork Asotin Creek in 1993 (Forest Service 1993f, unpublished work). The North Fork of Asotin Creek on USFS lands averaged 7.7 pools per mile (3.7% stream surface area) in 1992 (Forest Service 1992g, unpublished work). Pool frequency on Lick Creek improved greatly from 0.2 pools per mile in 1994 to 16 pools per mile in 1996 (Forest Service 1998, unpublished work). A total of 34 pools were identified on the lower 0.8 miles (downstream from USFS lands) of the North Fork Asotin Creek which equates to 43 pools per mile (Natural Resources Conservation Service (USDA) 2001).

Pool Quality

Average residual pool depth on North Fork Asotin Creek on USFS lands was 1.8 feet when surveyed in 1992 (Forest Service 1992g, unpublished work). Pools downstream from USFS lands were fairly deep with 58% of pools on the lower 0.8 miles of stream being two to three feet deep (Natural Resources Conservation Service (USDA) 2001). Residual pool depth on South Fork of North Fork Asotin Creek was 1.2 feet (Forest Service 1993f, unpublished work). Pools on Cougar Creek were shallower with a residual depth of 1 foot (Forest Service 1992c, unpublished work).

Off-Channel Habitat

Side channels represented 1.7% of stream surface area of North Fork Asotin Creek during 1992 USFS surveys (Forest Service 1992g, unpublished work). No off-channel habitat was observed on the USFS portion of Lick Creek when surveyed in 1994 (Forest Service 1994c, unpublished work).

Water Quality/Temperature

The average seven-day maximum water temperature on North Fork Asotin Creek from the headwaters to Lick Creek (1992 to 2000) was 64 °F. The average maximum temperature for Lick Creek during the same time period was 60 °F (Forest Service (USDA) 2001, unpublished work). Daily maximum water temperatures at the USFS boundary did not exceed 63 °F in summer 2000 and ranged from 60 °F to 65 °F during the summer of 2001 (Mendel 2002b, personal communication). Temperatures in upstream reaches are generally cooler than those measured at the Forest Service Boundary (TAG 2002, personal communication).

Water Quantity/Dewatering

Summer flows on North Fork Asotin Creek generally average about 20 cfs (Mendel 2001, personal communication). Flows on North Fork Asotin Creek averaged 16 cfs in August 1992 (Forest Service 1992g, unpublished work). South Fork of N.F. Asotin Creek, Middle Branch, and Cougar Creek contribute up to 7 cfs each to summer flows in North Fork Asotin Creek (Asotin County Conservation District 1995). Two miles of dry channel were encountered on 5.6 miles of Lick Creek surveyed on USFS lands in 1994. Flow at the USFS boundary was 0.5 cfs at the time (Forest Service 1994c, unpublished work).

Change in Flow Regime

U.S. Forest Service equivalent clearcut acre (ECA) modeling indicates that the watershed is in good condition (Groat 2001, personal communication).

Biological Processes

Spring chinook were extirpated from the watershed in the early 1990s. Steelhead abundance is moderate and bull trout populations are greatly reduced (Mendel 2001, personal communication).

South Fork Asotin Creek

Habitat Ratings

Fish Passage

No passage barriers are known to exist on South Fork Asotin Creek (Mendel 2001, personal communication).

Screens and Diversions

No irrigation diversions are known to be in use on South Fork Asotin Creek (Mendel 2001, personal communication)

Riparian Condition

Mature and second growth Douglas-fir and grand fir dominate the riparian zone from the USFS boundary (RM 8.0) upstream to RM 10.5. Alder dominates the understory (Forest Service 1993e, unpublished work). Riparian vegetation from the USFS boundary downstream to Schlee's is in relatively good condition with some areas still recovering from the 1973 flood. The flood also caused considerable damage at the Schlee livestock operation leaving the stream totally exposed to the sun (Mendel 2001, personal communication). Asotin County Conservation District implemented a riparian replanting project at this site. Young cottonwood, willow, and alder are beginning to rapidly revegetate the riparian zone (Johnson 2001, personal communication). Riparian vegetation along the lower portion of South Fork Asotin Creek on state lands was severely damaged during the 1973 flood, but rapid regrowth is taking place (Mendel 2001, personal communication).

Streambank Condition

Most banks are relatively stable. A few areas remain damaged from floods and exhibit braiding (Mendel 2001, personal communication). This was a problem at the Schlee site discussed above until Asotin County Conservation District implemented a meander reconstruction project. The stream now flows through a single thread channel with young riparian vegetation helping to stabilize streambanks (Johnson 2001, personal communication).

Floodplain Connectivity

Logging upstream from RM 10.5 led to increased channel incision (Forest Service 1993e, unpublished work). The stream generally has access to the floodplain with the exception of encroachment from an old road above the Schlee property and South Fork Asotin Road running parallel to the stream from the mouth up to the Schlee property (Mendel 2001, personal communication).

Width/Depth Ratio

Data from summer 1986 WDFW stream surveys were used to calculate a width/depth ratio of 55.5 on lower South Fork Asotin Creek (Schuck *et al.* 1988). In 1993, the width/depth ratio on 2.5 miles of stream within USFS lands was 8 (Forest Service 1993e, unpublished work). The Snake River Lab reported two width/depth ratios (43.8 & 76.6) on the lower South Fork in 1998 (Mendel 2002b, personal communication).

Substrate Embeddedness

Embeddedness on USFS lands was 31% in 1993. The logging discussed above likely contributed to the high embeddedness levels (Forest Service 1993e, unpublished work). During

1993 pebble counts high substrate embeddedness was observed. However, no cobble embeddedness was encountered in 2000. The 1996-97 floods mobilized the streambed and flushed out fine sediment (Natural Resources Conservation Service (USDA) 2001). South Fork Asotin Creek contributes about 8% of the fine sediment load of Asotin Creek (Asotin County Conservation District 1995).

Large Woody Debris

Large wood was abundant in 1993 with 76.5 pieces per mile counted on 2.5 miles of stream surveyed on USFS lands (Forest Service 1998, unpublished work). Large woody debris is fairly limited on the lower portion of South Fork Asotin Creek on state lands. For example, WDFW Snake River Lab reported percent LOD (Large Organic Debris) values of 0.02% and 2.34% in 1998 (Mendel 2002b, personal communication).These areas were salvage logged following the 1973 flood, removing existing LWD and reducing future recruitment (Mendel 2001, personal communication).

Pool Frequency

In 1993, pools were not common on USFS lands with 9.6 per mile (3.7% of stream surface area) reported (Forest Service 1993e, unpublished work). A total of 115 pools were identified on the lower 3.5 miles of the South Fork Asotin Creek, or 33 pools per mile (Natural Resources Conservation Service (USDA) 2001). The Snake River Lab reported percent pool values (% of stream surface area) of 0.65% and 4.74% in 1998 (Mendel 2002b, personal communication).

Pool Quality

Residual pool depth on USFS lands was 1.1' when surveyed in 1993 (Forest Service 1993e, unpublished work). None of the pools assessed downstream from the USFS boundary were greater than three feet deep and 80% (92) were less than two feet deep (Natural Resources Conservation Service (USDA) 2001). The Snake River Lab developed average pool ratings (scale of 1 to 5, with 1 = poor, 5 = good) of 1 and 1.5 in 1998. The best rating was a value of 2 (Mendel 2002b, personal communication).

Off-Channel Habitat

Some off-channel habitat is present (Mendel 2001, personal communication).

Water Quality/Temperature

Mean water temperatures through mid-May 1987 exceeded 60 °F only five times. Daily maximum temperatures were generally between 60 °F and 70 °F from early April through mid-May (Schuck *et al.* 1988). The average seven-day maximum water temperature on South Fork Asotin Creek from 1992 to 2000 was 60 °F at the USFS boundary, and 71 °F (1992 & 1995) downstream on private land near the mouth (Forest Service (USDA) 2001, unpublished work). Daily maximum water temperatures near the mouth ranged from 65 °F to 73 °F during summer 2000 and 2001. Temperatures at RM 4.0 were similar in summer 2000 (Mendel 2002b, personal communication).

Water Quantity/Dewatering

South Fork Asotin Creek gets low in the summer, but never dewaters. Flows are generally about 1 to 3 cfs (Mendel 2001, personal communication). WDFW measured a flow of 2.4 cfs in mid-August 1986 (Schuck *et al.* 1988).

Change in Flow Regime

The natural flow regime is presumed to be present (Mendel 2001, personal communication).

Biological Processes

Reduced levels of marine-derived nutrients contributed by anadromous fish (i.e. eggs, juveniles, and decomposing carcasses) likely limit productivity (Mendel 2002a, personal communication).

Asotin Creek (Forks to mouth of George Creek)

Habitat Ratings

Fish Passage

Headgate Dam (RM 8.7) may be a partial barrier to some age classes at certain flows. The Cloverdale Road Bridge crossing may also be a partial barrier (Mendel 2001, personal communication).

Screens and Diversions

All of the diversions identified in Parkhurst (1950) and McIntosh (1989b) were either abandoned or screened by 1994 (Asotin County Conservation District 1995).

Riparian Condition

The floods of 1964 and 1974 removed much of the riparian vegetation. Landowners then built dikes, removed the remaining large trees, and relocated the stream channel to protect property (Asotin County Conservation District 1995). Trees had recolonized the riparian zone by 1993 as canopy cover averaged 60 to 80%, but the 1996-97 floods removed a large portion of the young trees. In 2000, canopy cover averaged just 20 to 40%. This cycle of catastrophic floods, over grazing, flood control measures, and road building led to the present degraded riparian condition. Only 16% of the creek had >70% canopy cover, while about 38% had <20% cover (Natural Resources Conservation Service (USDA) 2001).

Streambank Condition

In 2000 about 10% of banks were classified as actively eroding (Natural Resources Conservation Service (USDA) 2001). The 1996-97 floods washed 18 junk vehicles into the channel of Asotin Creek. In the summer of 1999 these vehicles were removed from the channel (Aiken 1999).

Floodplain Connectivity

Asotin Road parallels the stream for the entire length of this reach.

Width/Depth Ratio

The Snake River Lab reported a mean width/depth ratio of 45.8 from 13 pre-construction site evaluations in 1998 and 1999 (Mendel 2002b, personal communication).

Substrate Embeddedness

During 1993 pebble counts high substrate embeddedness was observed from Charley Creek downstream (Asotin County Conservation District 1995). However, no cobble embeddedness was encountered in 2000. The 1996-97 floods mobilized the streambed and flushed out fine sediment (Natural Resources Conservation Service (USDA) 2001).

Large Woody Debris

Large woody debris (LWD) levels increased substantially between the 1993 and 2000 assessments. From Charley Creek downstream to Headgate Dam LWD increased 195%, while it increased 89% from Headgate Dam downstream to George Creek. The LWD was recruited during the 1996-97 flood events (Natural Resources Conservation Service (USDA) 2001). The Snake River Lab calculated a mean percent LOD (Large Organic Debris) of 1.64% from 13 pre-construction site evaluations in 1998 and 1999 (Mendel 2002b, personal communication).

Pool Frequency

The Natural Resource Conservation Service (NRCS) identified 964 pools on this 13.2-mile long reach, or 73 pools per mile. Large pools greater than three feet deep occurred at 9.1 pools per mile. A 1990 to 1992 survey of Asotin Creek (McIntosh *et al.* 1994) inventoried only pools >3 feet deep with surface area >215 square feet. These pools occurred at 3.7 per mile (Natural Resources Conservation Service (USDA) 2001). The Snake River Lab calculated a mean percent pool (% of stream surface area occupied by pools) of 2.87 from 13 pre-construction site evaluations in 1998 and 1999 (Mendel 2002b, personal communication).

Pool Quality

The majority of pools on this reach (844) were shallow with a depth of one to two feet. Large pools greater than three feet deep comprised 12.4% of pools assessed. Boulders are a common habitat-forming feature, with 739 noted in the assessment. Under-cut banks and over-head cover were also observed with 192 and 257 occurrences of each respectively (Natural Resources Conservation Service (USDA) 2001). The Snake River Lab reported a mean pool rating of 1.46 (scale of 1 to 5, 1 = poor, 5 = good) from 13 pre-construction site evaluations in 1998 and 1999. No pools were rated higher than 3 (Mendel 2002b, personal communication).

Off-Channel Habitat

Off-channel habitat is very limited but some is present (Mendel 2001, personal communication).

Water Quality/Temperature

Average monthly temperatures (2 samples/month) at all seven stations along this reach of Asotin Creek exceeded the Washington State Class A standard of 18 °C (64.4 °F) during July 1998 and 1999. Average temperatures for the same stations during August 1998 and 1999 exceeded 16.4 °C (61.5 °F) at all stations. Total suspended solids did not appear to be causing problems, with levels decreasing as one moved downstream (Gephart *et al.* 2000). Daily maximum water temperatures at the forks exceeded 70 °F for three days, but ranged from 65 °F to 70 °F all other days in summer 2001. Daily maximum temperatures at Headgate Park ranged from 67 °F to 75 °F in summer 2000. Most maximums were slightly greater than 70 °F in summer 2001, but 75 °F was exceeded one day. Daily maximum temperatures above George Creek ranged from 67 °F to 76 °F in summer 2000 and exceeded 75 °F for five days in summer 2001. (Mendel 2002b, personal communication).

Water Quantity/Dewatering

No dewatering occurs. Summer flows average about 20 cfs (Mendel 2001, personal communication).

Change in Flow Regime

A total of 5 cfs of flow are allowed to be continuously diverted from the Asotin Creek mainstem. WDF and WDG made requests to limit diversions by junior water right holders to maintain a flow of 10 cfs year-round at Headgate Dam (Asotin County Conservation District 1995).

Biological Processes

Reduced levels of marine-derived nutrients contributed by anadromous fish (i.e. eggs, juveniles, and decomposing carcasses) likely limit productivity (Mendel 2002a, personal communication).

Asotin Creek (George Creek to mouth)

Habitat Ratings

Fish Passage

No barriers are known on this reach (Mendel 2001, personal communication).

Screens and Diversions

About 10 small pump diversions used to water lawns are estimated to be in use on this reach (Johnson 2001, personal communication). No information on screening compliance was available.

Riparian Condition

The riparian buffer along this reach is very constricted by development. Vegetation has been damaged substantially by grazing (Mendel 2001, personal communication). Young alders that recolonized following the 1964 flood are the primary vegetation (Johnson 2001, personal communication)

Streambank Condition

This reach has been channelized and armored extensively to protect roads and private property. Cobble berms have been constructed in some areas (Mendel 2001, personal communication, Johnson 2001, personal communication).

Floodplain Connectivity

Channelization and dike construction have eliminated all floodplain connectivity on this short reach (Mendel 2001, personal communication, Johnson 2001, personal communication).

Width/Depth Ratio

The stream has responded to channelization by developing an overly wide and shallow channel ("F" under the Rosgen classification system) (Johnson 2001, personal communication).

Substrate Embeddedness

As of 1984, sheet and rill erosion of cropland carried 24,000 tons per year of fine sediment to Asotin Creek (USDA Soil Conservation Service *et al.* 1984). During 1993 pebble counts high substrate embeddedness was observed. The Natural Resources Conservation Service (USDA) (2001) stream assessment did not inventory this reach of Asotin Creek (began at George Creek and worked upstream). Embeddedness is presumed to substantial (TAG 2002, personal communication) since George and Pintler Creeks contribute the majority of fine sediment to Asotin Creek (54%) (Asotin County Conservation District 1995).

Large Woody Debris

Very little LWD is present and there is little potential for near-term recruitment because of channelization and the immaturity of trees currently found in the limited riparian buffer (Johnson 2001, personal communication).

Pool Frequency

This reach was not inventoried in 1993 or 2000. Channelization and low LWD abundance likely severely limit pool formation (TAG 2001, personal communication).

Pool Quality

Limited pocket pools are present downstream from large boulders and cobble (Johnson 2001, personal communication).

Off-Channel Habitat

Off-channel habitat has been eliminated by channelization and diking of the stream channel (Johnson 2001, personal communication).

Water Quality/Temperature

Mean water temperatures measured at the smolt trap on Asotin Creek through early June 1986 never exceeded 62 °F. Daily maximum water temperatures exceeded 70 °F only once (Schuck *et al.* 1988). Average water temperatures (measured twice per month) at the mouth of George Creek and Asotin City Park both exceeded 19 °C (66.2 °F) in July 1998 and 1999. Average temperatures for August 1998 and 1999 were 20.6 °C (69.0 °F) and 17.7 °C (63.9 °F) for the mouth of George Creek and Asotin City Park respectively. The site at the mouth of George Creek had the highest values of any station on Asotin Creek. Total suspended solids did not appear to be a problem on this reach in 1998 and 1999 (Gephart *et al.* 2000). The Snake River Lab recorded daily maximum water temperatures from 70 °F to 79 °F below George Creek in summer 2000 and 75 °F to 80 °F at the Asotin City Park in summer 2001. Fifteen days exceeded 75 °F at the City Park (Mendel 2002b, personal communication).

Water Quantity/Dewatering

Permits, claims, and certificates on file with WDOE identify a potential instantaneous withdrawal of 2.80 cfs of flow from Asotin Creek (Neve 2001, personal communication). No work has been undertaken to quantify the number of diversions and amount of water withdrawn from this reach (TAG 2002, personal communication).

Change in Flow Regime

A total of 5 cfs of flow are allowed to be continuously diverted from the Asotin Creek mainstem. WDF and WDG made requests to limit diversions by junior water right holders to maintain the following flows: 15 cfs July 1 to March 31 at Hwy 128 and 70 cfs April 1 to June 30 at Hwy 128 (Asotin County Conservation District 1995).

Biological Processes

Reduced levels of marine-derived nutrients contributed by anadromous fish (i.e. eggs, juveniles, and decomposing carcasses) likely limit productivity (Mendel 2002a, personal communication).

Charley Creek

Habitat Ratings

Fish Passage

A culvert under Asotin Creek Road on Charley Creek should be evaluated to see if it is a fish passage barrier (Mendel 2001, personal communication).

Screens and Diversions

Two diversions are in use on the lower 1 to 2 miles of Charley Creek. The 1996-97 floods damaged the diversions. Screens that meet state and federal criteria were installed following the floods (Johnson 2002, personal communication).

Riparian Condition

Large patches of native woody plants have been removed from the riparian zone along the lower five miles of Charley Creek. Riparian overstory and understory vegetation is absent or very limited from the mouth to RM 8 in areas of heavy cattle grazing. Portions of the riparian zone on U.S. Forest lands upstream from RM 8 have also been degraded by grazing and logging (Forest Service 1996, unpublished work). However, alders provide a canopy cover of 90% on the portion of stream below Asotin Creek Road (Natural Resources Conservation Service (USDA) 2001). The 1996 flood removed or damaged a large amount of riparian vegetation along Charley Creek, especially the lower reaches upstream from the mouth. (Forest Service 1996, unpublished work). Livestock grazing and channel incision with the associated drop in water table have also contributed to riparian degradation (Natural Resources Conservation Service (USDA) 2001).

Streambank Condition

An assessment of the lower five miles of stream in summer of 2000 revealed that 28.4% of the assessed channel is a gulley stream type (Rosgen stream type "G"). The stream is highly entrenched in these areas and banks are actively eroding as the stream attempts to recreate a floodplain (Natural Resources Conservation Service (USDA) 2001). Cattle grazing has left little bank cover and caused very unstable streambanks from the mouth to about RM 8 (Forest Service 1996, unpublished work).

Floodplain Connectivity

The majority of the lower five miles of Charley Creek has lost access to the historic floodplain because of channel incision (Natural Resources Conservation Service (USDA) 2001). The incision likely started in 1964 when two earthen dams were destroyed in a flood. The dams were constructed in the 1950s or 1960s by Washington Department of Game (WDG) to impound water for trout fishing ponds (Mendel 2001, personal communication). The stream is confined between dikes from the Asotin Creek Road downstream to the mouth (Natural Resources Conservation Service (USDA) 2001).

Width/Depth Ratio

Width/depth ratios on the USFS portion of Charley Creek averaged 5.3 in 1993, then increased to 9.3 in 1996 (Forest Service 1998, unpublished work). The lower five miles of Charley Creek are predominately narrow-entrenched stream channels with a low width/depth ratio (Natural Resources Conservation Service (USDA) 2001). The Snake River Lab reported a mean width/depth ratio of 26.1 from eight pre-construction site evaluations from 1998 to 2001 (Mendel 2002b, personal communication).

Substrate Embeddedness

Embeddedness on the USFS portion of Charley Creek averaged 15.3% in 1993 (Forest Service 1998, unpublished work). Substrate is highly embedded downstream from the Asotin Creek Road (Natural Resources Conservation Service (USDA) 2001). Charley Creek contributes about 5% of the fine sediment load of Asotin Creek (Asotin County Conservation District 1995).

Large Woody Debris

Large woody debris levels declined sharply from 1993 to 1996 on USFS lands. In 1993 LWD per mile averaged 88 pieces, while in 1996 it decreased to 18.9 pieces (Forest Service 1998, unpublished work). Conditions downstream from forest service lands were far worse. The Snake River Lab found no LWD during 1998, 2000, and 2001 pre-construction site evaluations (Mendel 2002b, personal communication).

Pool Frequency

Considering the decrease in LWD discussed above, pool frequency surprisingly increased from an average of 11.2 pools per mile in 1993 to 25.7 pools per mile in 1996 on USFS lands (Forest Service 1998, unpublished work). Pools were less numerous downstream from forest service lands. The Snake River Lab reported an average percent pool value (% of stream surface area comprised of pools) of 1.24% from seven pre-construction site evaluations from 1998 to 2001 (Mendel 2002b, personal communication).

Pool Quality

No pools greater than 3' deep were identified in the lower five miles of Charley Creek (Natural Resources Conservation Service (USDA) 2001). Mean residual pool depth was 1.1 feet from the mouth to RM 12.7 when surveyed in 1996 (Forest Service 1996, unpublished work). The Snake River Lab reported a mean pool rating of 1.29 from six pre-construction site evaluations from 1998 to 2001 (scale of 1 to 5, 1 = poor, 5 = good). No pools were rated higher than 2 (Mendel 2002b, personal communication).

Off-Channel Habitat

No off-channel habitat is present on Charley Creek (Mendel 2001, personal communication).

Water Quality/Temperature

Monitoring through late June 1986 and late May 1987 detected mean temperatures generally less than 60 °F with maximum temperatures reaching or exceeding 80 °F on two occasions in June (Schuck *et al.* 1988). The average seven-day maximum water temperature on Charley Creek at forest road 4206 from 1992 to 2000 was 59 °F (Forest Service (USDA) 2001, unpublished work). Daily maximum water temperatures at RM 2.0 ranged from 60 °F to 64 °F during summer 2000 and 2001. Maximum temperatures downstream at the mouth ranged from 67 °F to 72 °F in summer 2000 and exceeded 70 °F one day in summer 2001 (Mendel 2002b, personal communication).

Water Quantity/Dewatering

No artificial dewatering occurs on Charley Creek. Flows from the spring of 1986 and 1987 ranged from seven to 14 cfs (Schuck *et al.* 1988). The stream is spring fed and generally maintains about 10 cfs of flow through the summer (Mendel 2001, personal communication). Flow throughout the stream was about 12 cfs when surveyed in July 1996 (Forest Service 1996, unpublished work).

Change in Flow Regime

The natural flow regime is presumed to be present (TAG 2001, personal communication).

Biological Processes

Several beaver dams are present on the lower 200' of Charley Creek. The dams are passable and provide rearing pools (Natural Resources Conservation Service (USDA) 2001). Reduced levels of marine-derived nutrients contributed by anadromous fish (i.e. eggs, juveniles, and decomposing carcasses) likely limit productivity (Mendel 2002a, personal communication).

George Creek (Headwaters to Wormell Creek) Including Coombs and Hefflefinger Creeks

Habitat Ratings

Fish Passage

A perched culvert at the Trent Ridge Road crossing and an in-channel pond may be partial barriers on this reach of George Creek (Mendel *et al.* 2001). A logjam on George Creek between RM 14.9 and 17.7 is a partial barrier (Mendel 2001, unpublished work). No barriers were noted on Coombs Creek from the USFS boundary upstream three miles (Forest Service 1993a, unpublished work). A logjam was identified as a partial barrier on Coombs Creek between RM 2.0 and the mouth. The barrier would be passable at high flows (Mendel 2001, unpublished work).

Screens and Diversions

No irrigation diversions are known to be in use on this reach (Mendel 2001, personal communication).

Riparian Condition

Functional riparian buffers were present throughout the entirety of this reach (Mendel *et al.* 2001). Mature and second growth Douglas-fir and grand fir dominated the riparian overstory on George Creek from the USFS boundary upstream 3.25 miles. Past clear cuts left no buffer along the stream (Forest Service 1993c, unpublished work). Deciduous and coniferous trees dominated the riparian zone along George Creek from RM 14.9 to RM 17.7. The buffer averaged 76.5' in width and 48' high. The average maximum height was 90'. Shading averaged 66% (Mendel 2001, unpublished work). Mature and second growth grand fir and Douglas-fir dominated the riparian zone on the USFS portion of Coombs Creek. Alder was the dominant shrub species. The reach from two to three miles above the USFS boundary is more accessible than the two miles downstream. Cattle grazing and logging likely damaged habitat on the upper reach. Shading was estimated at 75% on the lower two miles of the surveyed reach, but only 56% on the upper reach (Forest Service 1993a, unpublished work). Coniferous trees with a shrub understory were the primary riparian plants on Coombs Creek from the mouth to RM 2.0. The buffer was 300' wide or greater with a mean height of 23' and average maximum height of 70'. Shading averaged 59% (Mendel 2001, unpublished work).

Streambank Condition

Bank stability on the USFS portion of George Creek was poor in areas of heavy cattle grazing. However, bank cover throughout the reach was estimated at 85% (Forest Service 1993c, unpublished work). Banks along George Creek on lands downstream from the USFS lands were generally stable. Erosion averaged 14% of banks from RM 14.9 to RM 17.7 (Mendel 2001, unpublished work). Some erosion was noted in flood damaged areas near Wormell Creek (Mendel 2001, personal communication). Coombs Creek had moderately damaged banks with an average of 32% active erosion. Little or no livestock damage was noted (Mendel 2001, unpublished work).

Floodplain Connectivity

Floodplains are naturally limited by the deep-v canyon and high stream gradient (Mendel 2001, personal communication).

Width/Depth Ratio

Width/depth ratio on USFS lands in 1993 was 9.4 on George Creek (Forest Service 1993c, unpublished work) and 13 on Coombs Creek (Forest Service 1993a, unpublished work). Width/depth ratio of George Creek from RM 14.9 to RM 17.7 was 15.6. The width/depth ratio of Coombs Creek from the mouth to RM 2.0 was 15.6 (Mendel 2001, unpublished work).

Substrate Embeddedness

Embeddedness on USFS lands was 43% on George Creek (Forest Service 1993c, unpublished work) and ranged from 11% to 29% on Coombs Creek in 1993. Embeddedness on Coombs Creek became more severe as one moved upstream toward the reach damaged by grazing and logging (Forest Service 1993a, unpublished work). Cobble was the dominant substrate on George Creek from RM 14.9 to RM 17.7 and Coombs Creek from the mouth to RM 2.0. Embeddedness was generally <25% (Mendel 2001, unpublished work). Fine sediment levels were generally moderate during year 2000 WDFW surveys (Mendel *et al.* 2001).

Large Woody Debris

Large woody debris averaged 122 pieces per mile in 1993 on 3.3 miles of George Creek located on USFS lands (Forest Service 1993c, unpublished work). Small debris jams were common on George Creek downstream from USFS lands during 2000 WDFW surveys (Mendel *et al.* 2001). However, woody debris was generally small in size (Mendel 2001, personal communication). On 2.2 miles of the USFS portion of Coombs Creek LWD averaged 76 pieces per mile in 1993 (Forest Service 1998, unpublished work). Small amounts of LWD were present on Coombs Creek from the mouth to RM 2.0 (Mendel 2001, unpublished work).

Pool Frequency

Pool frequency on the USFS reaches discussed under LWD averaged 16 per mile for George Creek (Forest Service 1993c, unpublished work) and 14 per mile for Coombs Creek in 1993 (Forest Service 1998, unpublished work). George Creek had 14.3 pools per mile from RM 14.9 to RM 17.7. Coombs Creek had 13.5 pools per mile from the mouth to RM 2.0 (Mendel 2001, unpublished work).

Pool Quality

Riffles with plunge and lateral scour pools dominate George Creek (Mendel *et al.* 2001). Cascades and riffles dominated habitat on George Creek from RM 14.9 to RM 17.7. Boulders and turbulence provided the majority of instream cover, although large amounts of LWD were present in some areas. Riffles and runs were the primary habitat type on Coombs Creek from the mouth to RM 2.0 (Mendel 2001, unpublished work). Residual pool depth on Coombs Creek in 1993 was 1.15 feet (Forest Service 1993a, unpublished work).

Off-Channel Habitat

Numerous side channels were present on George Creek from RM 14.9 to RM 17.7 and Coombs Creek from the mouth to RM 2.0 (Mendel 2001, unpublished work).

Water Quality/Temperature

The average seven-day maximum water temperature from 1992 to 2000 on George Creek at the USFS boundary was 59 °F. The average maximum temperature on Coombs Creek (1995) was 57 °F (Forest Service (USDA) 2001, unpublished work). Summer 2000 water temperatures on this reach of George Creek were excellent for salmonids with only one maximum reading >65 °F and average temperatures for the entire monitoring period <60 °F (Mendel *et al.* 2001). Mean water temperatures at RM 17.5 reached 60 °F only once and maximum temperatures never exceeded 65 °F for the summer of 2001 (Mendel 2001, unpublished work). George Creek carries very high fine sediment loads (Asotin County Conservation District 1995).

Water Quantity/Dewatering

July 2000 flows on this reach of George Creek ranged from 1.09 cfs below the Trent Ridge Road culvert (RM 17.5) to 1.72 cfs below Hefflefinger Creek. Hefflefinger and Coombs Creeks both had flows of about 0.4 cfs during the summer of 2000 (Mendel *et al.* 2001). Flow at RM 17.5 was 6.34 cfs on April 18, 2001; 7.30 cfs on May 8, 2001, and 0.54 cfs on July 12, 2001 (Mendel 2001, unpublished work). Portions of George Creek near Trent Ridge Road went dry during the 2001 drought (Mendel 2001, personal communication).

Change in Flow Regime

The upper reaches of George Creek are perennial (Asotin County Conservation District 1995). No change in flow regime is known to have occurred (TAG 2001, personal communication).

Biological Processes

Reduced levels of marine-derived nutrients contributed by anadromous fish (i.e. eggs, juveniles, and decomposing carcasses) likely limit productivity (Mendel 2002a, personal communication).

George Creek (Wormell Creek to mouth)

Habitat Ratings

Fish Passage

George Creek often goes dry for about ½ mile downstream from Pintler Creek during the summer (Asotin County Conservation District 1995, Mendel 2001, personal communication). No barriers were observed from RM 4.5 to RM 5.7 or RM 1.6 to RM 3.6 (Mendel 2001, unpublished work).

Screens and Diversions

Two or three diversions are thought to be in use. They are presumed to be screened to state and federal criteria (Johnson 2001, personal communication).

Riparian Condition

Riparian buffers on this reach from ½ mile above Stringtown Gulch to the mouth were patchy and ranged from areas of functional vegetation to limited vegetation (Mendel *et al.* 2001). This reach of stream was severely damaged by floods (USDA Soil Conservation Service *et al.* 1981b). Deciduous trees with an understory of grasses and shrubs were the primary riparian vegetation from RM 4.5 to RM 5.7. The buffer averaged 17' wide with a mean height of 12' and maximum height of 28'. Shading averaged 30.5%. Riparian buffer composition from RM 1.6 to RM 3.6 was similar to the previous reach. However, the buffer averaged 37' wide with a mean height of 48' and maximum height of 60'. Shading averaged 49% (Mendel 2001, unpublished work). Transient channels and heavy bedload accumulation have maintained the degraded riparian condition (Kuttel 2001b).

Streambank Condition

Bank stability was correlated with riparian condition, with stable banks present in areas of functional riparian buffers and unstable banks in areas lacking riparian vegetation (Mendel *et al.* 2001). From RM 4.5 to RM 5.7, banks were stable with little or no evidence of livestock damage. Average bank erosion was 10.5%. Banks from RM 1.6 to RM 3.6 were severely damaged and unstable in areas of high intensity livestock grazing. An average of 46% of banks were eroding (Mendel 2001, unpublished work).

Floodplain Connectivity

Evidence of severe flooding was evident along much of George Creek during 1981 stream surveys. Historically the floodplain occupied the entire valley floor of the lower end of George Creek. This area was planted to orchards, but floods wiped out the trees and all of the soil. Pintler Creek appeared to be responsible for a large portion of the flood damage on this reach of the stream (USDA Soil Conservation Service *et al.* 1981b). The channels have full access to the floodplain on the reach just upstream from the mouth. The floodprone area of channels on this reach ranged from 70 to 442 feet (Kuttel and others 2001, unpublished work). The floodplain is accessible from RM 4.5 to RM 5.7. Portions of the floodplain were not accessible from RM 1.6 to RM 3.6 (Mendel 2001, unpublished work).

Width/Depth Ratio

The channel of lower George Creek is generally braided. Several bankfull channels are present in this area of heavy aggradation. Channels on this reach are wide and shallow with width/depth ratios ranging from 25 to 159 (Kuttel and others 2001, unpublished work). Width/depth ratio was 30.6 from RM 4.5 to RM 5.7 and 23 from RM 1.6 to RM 3.6. (Mendel 2001, unpublished work).

Substrate Embeddedness

Fine sediment levels were particularly high on George Creek from ½ mile above Stringtown Gulch to the mouth (Mendel *et al.* 2001). Cobble was the dominant substrate from RM 4.5 to RM 5.7 and RM 1.6 to RM 3.6. Embeddedness was generally <25% from RM 4.5 to RM 5.7 and 25 to 50% from RM 1.6 to RM 3.6 (Mendel 2001, unpublished work). George and Pintler Creeks contribute the majority of fine sediment to Asotin Creek (54%) (Asotin County Conservation District 1995).

Large Woody Debris

Young riparian vegetation recovering from past floods limits LWD recruitment (Johnson 2001, personal communication). Little LWD was present from RM 4.5 to RM 5.7 or RM 1.6 to RM 3.6 (Mendel 2001, unpublished work).

Pool Frequency

Pool frequency was 12.5 pools per mile from RM 4.5 to RM 5.7 and 7 pools per mile from RM 1.6 to RM 3.6 (Mendel 2001, unpublished work).

Pool Quality

George Creek's channel morphology is dominated by riffles with plunge and lateral scour pools (Mendel *et al.* 2001). Turbulence was the dominant instream cover (Mendel 2001, unpublished work).

Off-Channel Habitat

No side channels were observed from RM 4.5 to RM 5.7. Numerous off-channel areas were found from RM 1.6 to RM 3.6 (Mendel 2001, unpublished work).

Water Quality/Temperature

Maximum water temperatures at Rockpile Creek (RM 4.0) from June through early August 2000 frequently exceeded 70 °F, but average temperatures exceeded 65 °F on only a few occasions (Mendel *et al.* 2001). Conditions deteriorated in 2001 with mean water temperatures at RM 4.0 frequently exceeding 65 °F from late June to mid-September 2001 and daily maximum temperatures often exceeding 75 °F (Mendel 2001, unpublished work). Interestingly, macroinvertebrates including stoneflies, mayflies, caddisflies, and water pennies were abundant in the braided reach just upstream from the mouth during the third week of July 2001 (Kuttel 2001b). These invertebrates require cold water to survive (Natural Resources Conservation Service (USDA) 1998). George Creek carries very high fine sediment loads (Asotin County Conservation District 1995).

Water Quantity/Dewatering

On April 27, 2000 the flow above Stringtown Gulch was 33.7 cfs. On April 21, 2000 the flow 0.4 miles above the mouth was 85.1 cfs and on April 26 the flow at the mouth was 44.8 cfs (Mendel *et al.* 2001). Flow at RM 1.4 was 21.70 cfs on April 18, 2001. On April 3, 2001, flow at RM 0.4 was 17.69 cfs (Mendel 2001, unpublished work). The reach from Pintler Creek downstream has gone dry most years since 1981 (Mendel 2001, personal communication).

Change in Flow Regime

The upper reaches of George Creek are perennial, but flow typically goes subsurface from the mouth of Pintler Creek downstream to Asotin Creek (Asotin County Conservation District 1995).

Biological Processes

Reduced levels of marine-derived nutrients contributed by anadromous fish (i.e. eggs, juveniles, and decomposing carcasses) likely limit productivity (Mendel 2002a, personal communication).

Pintler Creek

Habitat Ratings

Fish Passage

Lower Pintler Creek goes dry most years. Several reaches upstream are also intermittent (Asotin County Conservation District 1995, Mendel 2001, personal communication).

Screens and Diversions

No diversions are known to be in use on Pintler Creek (Mendel 2001, personal communication, Johnson 2001, personal communication).

Riparian Condition

Young alder, cottonwood, and willow are the dominant vegetation along Pintler Creek from Nimms Creek to the mouth. The buffer ranges from partially functioning to degraded (Mendel *et al.* 2001). From Ayers Gulch to the mouth riparian vegetation is severely degraded. The floodplain is primarily a wide cobble bar. Cottonwood and alder dominate the floodplain upstream from Ayers Gulch (Mendel 2001, personal communication).

Streambank Condition

Banks were relatively stable in areas with functional riparian buffers, and unstable in areas of riparian degradation (Mendel *et al.* 2001). The 1996 flood caused some erosion, but it is not prevalent (Mendel 2001, personal communication).

Floodplain Connectivity

The stream has full access to the floodplain. No dikes or roads are present to prevent flooding (Johnson 2001, personal communication).

Width/Depth Ratio

The channel was wide and shallow in areas with degraded riparian condition. The channel was narrow in areas with functional riparian buffers (Mendel *et al.* 2001).

Substrate Embeddedness

Fine sediment levels were generally high throughout the reach surveyed from Nimms Creek downstream to the mouth. A film of fine sediment covered the majority of the substrate (Mendel *et al.* 2001). George and Pintler Creeks contribute the majority of fine sediment to Asotin Creek (54%) (Asotin County Conservation District 1995).

Large Woody Debris

Moderate levels of LWD were present in reaches with woody riparian vegetation. LWD was absent in areas of degraded and/or denuded riparian vegetation (Mendel 2001, personal communication).

Pool Frequency

Pools were relatively common in reaches with woody vegetation, but rarely encountered in areas of riparian degradation (Mendel 2001, personal communication).

Pool Quality

Pintler Creek has a moderate to high gradient with small riffles and plunge pools. Some relatively large and deep (2 to 3 feet) pools were present during year 2000 WDFW surveys (Mendel *et al.* 2001).

Off-Channel Habitat

No off-channel habitat was present on Pintler Creek (Mendel 2001, personal communication).

Water Quality/Temperature

Maximum water temperatures from late June to early August 2000 frequently exceeded 70 °F downstream from Nimms Gulch. Average temperatures often exceeded 65 °F from July through mid-August. Maximum water temperatures never exceeded 65 °F on lower Pintler Creek near the mouth during year 2000 monitoring and average temperatures rarely exceeded 60 °F at this site (Mendel *et al.* 2001). The low temperatures were caused by a spring returning to surface flow at the thermograph site (Mendel 2001, personal communication). Pintler Creek carries very high fine sediment loads at times (Asotin County Conservation District 1995).

Water Quantity/Dewatering

Wide shallow areas of the channel often went dry during the summer of 2000. Flows ranged from 1.64 cfs measured 0.5 miles above the mouth on April 26, 2000 to 0.24 cfs measured above Kelly Gulch on July 24, 2000 (Mendel *et al.* 2001).

Change in Flow Regime

The natural flow regime is presumed to be present (TAG 2001, personal communication).

Biological Processes

Reduced levels of marine-derived nutrients contributed by anadromous fish (i.e. eggs, juveniles, and decomposing carcasses) likely limit productivity (Mendel 2002a, personal communication).

ASOTIN SUBBASIN RECOMMENDATIONS

Protect relatively high quality salmonid habitat on North Fork Asotin Creek, Middle Branch North Fork Asotin Creek, South Fork of North Fork Asotin Creek, Cougar Creek, and George Creek upstream from Wormell Creek.

Restore a functional channel on lower George Creek from Pintler Creek downstream through meander reconstruction and restoration of woody riparian vegetation on the floodplain.

Evaluate fish passage at the culvert under Asotin Creek Road at the Charley Creek crossing and replace the culvert if necessary.

Evaluate fish passage at Headgate Dam and improve passage if necessary.

Continue to reduce fine sediment deposition through implementation of no-till/direct seed farming, riparian buffers, strip cropping, sediment basins, terraces, grassed waterways, and other BMPs.

Reduce summer stream temperatures and improve channel and bank stability through restoration of riparian forest buffers along subbasin streams, particularly mainstem Asotin Creek, portions of South Fork Asotin Creek, lower Lick Creek, lower Charley Creek, George Creek downstream from Wormell Creek, and lower Pintler Creek.

Inventory surface water diversions on Asotin Creek from George Creek to the mouth and evaluate compliance with state and federal screening requirements. Screen diversions where necessary.

In the short term, increase complexity of instream habitat through installation of large woody debris, creation of pools in limited locations selected by technical experts. Reliance on instream projects should be minimized since they largely treat symptoms, rather than addressing the root cause(s) of habitat degradation.

In the long term, attempt to restore “normative” function of streams through removal or setback of dikes, meander reconstruction, and riparian reforestation.

Practice proper riparian vegetation management to ensure healthy vigorous plant growth of woody vegetation and natural regeneration. Best management practices (BMPs) could include, but are not limited to: limited riparian “flash grazing,” pasture rotation, fencing livestock out of streams and riparian areas, and development of off-site watering facilities.

Inventory habitat conditions as well as fish presence and relative abundance on Asotin Creek and tributary streams every five years to fill data gaps and monitor success of habitat restoration projects. Conduct continuous monitoring of water quality parameters such as water temperature and total suspended solids.

Enforce existing land use regulations including Critical Area Ordinances, Shoreline Management Act, and the Growth Management Act.

ALPOWA-DEADMAN SUBBASIN HABITAT LIMITING FACTORS

Alpowa-Deadman Subbasin Description

The Alpowa-Deadman Subbasin encompasses the watersheds of Alpowa, Deadman, and Meadow Creeks (336 square miles). Alpowa Creek originates from springs at the northeast terminus of the Blue Mountains at an elevation of about 3,280 feet and outlets at the Snake River (RM 131) at about 740 feet elevation. Deadman and Meadow Creeks flow from springs in the Palouse hills south of the Snake River and north of US highway 12. Both streams enter the Snake River at (RM 83) near State Route 127 (See Map 14). Dryland agriculture is the dominant land use on ridge tops, while livestock grazing is the dominant land use on canyon side slopes and valley bottoms (See Figure 17). Some irrigated wheat and alfalfa are grown in the valley bottoms of Deadman and Meadow Creeks, while horticulture is practiced near the mouth of Alpowa Creek. No towns of notable size are present. The population is spread uniformly throughout farmsteads. Topography is characterized by deep v-shaped valleys in headwater areas gradually widening into comparatively broad valley bottoms on the mainstem of each stream. The landscape is the result of folding and faulting of extensive deposits of Columbia River Basalts. Highly erodible loess soils on the plateau tops support extensive acreages of dryland farming. There is generally a large difference in elevation between the valley bottoms and the surrounding plateaus. Intermittent and/or ephemeral streams are present throughout the watershed. Under typical conditions these streams do not convey much water, but during thunderstorms or rain-on–snow events they are capable of carrying immense debris torrents into mainstem streams. The sediment moving capacity of these small streams is easily seen in the extensive alluvial fans deposited at their mouths. Major storms often carry immense fine sediment loads to Meadow and Deadman Creeks. The 1964-65 floods yielded a total suspended solids concentration of nearly 400,000 mg/L (Esmaili and Associates 1982). Habitat conditions in the Alpowa-Deadman Subbasin are generally poor to fair (See Table 10).

Summer steelhead, and resident rainbow trout are present in Alpowa Creek and lower Deadman Creek. Summer steelhead/resident rainbow are presumed to be present in Meadow Creek and both of its forks as well as North and South Deadman Creek (See Appendix B).

Figure 17. Rangeland along Ben Day Creek (tributary of Meadow Creek) damaged by heavy grazing. Photographed September 2001.

Alpowa Creek (Headwaters to Stember Creek)

Habitat Ratings

Fish Passage

No barriers are known (Mendel 2001, personal communication).

Screens and Diversions

Pomeroy Conservation District estimates that 10 surface water diversions are in use in the Alpowa Creek Watershed (Northwest Power Planning Council 2001c). No information on screening compliance was available.

Riparian Condition

The lower end of Stember Creek is heavily grazed, leaving no vegetation on streambanks. Cattle grazing has removed or damaged woody riparian vegetation from Stember Creek at least five miles upstream (Northwest Power Planning Council 2001c). Numerous riparian areas upstream from Stember Creek have been degraded or denuded. However, about 1 mile of functional riparian vegetation is present near Robinson Canyon (Mendel 1999) and likely provides a reference of the historic condition. Riparian degradation is a major limiting factor on Alpowa Creek (Mendel 2001, personal communication). Pomeroy Conservation District has enrolled 53 acres near the mouth of Stember Creek in the CREP (Bartels 2002, personal communication).

Streambank Condition

Removal of woody riparian vegetation by cattle grazing and channelization has caused erosion of streambanks (Northwest Power Planning Council 2001c). In 1981, grazing was heavy from Stember Creek upstream to springs that supply perennial flow. Trees were in "fair" condition on 60% of banks and "poor" condition on the remaining 40%. Shrubs were in "poor" condition on 60% of banks and lacking on the remaining 40% (USDA Soil Conservation Service *et al.* 1981a).

Floodplain Connectivity

The stream generally has access to the floodplain, but some reaches have incised (Mendel 2001, personal communication).

Width/Depth Ratio

The stream is overly wide and shallow in areas of riparian degradation, but areas with functional riparian vegetation are generally more narrow and deep (Mendel 2001, personal communication).

Substrate Embeddedness

In 1981 embeddedness ranged from 36% to 50% on this reach (USDA Soil Conservation Service *et al.* 1981a). Substrate on this reach consists of an assortment of gravel, rubble, cobble, and boulders. In 1999 embeddedness was 50% with a layer of fine sediment covering all rock surfaces (Catts and Rabe 2000).

Large Woody Debris

Over grazing and channelization have damaged or removed riparian vegetation, severely limiting large woody debris recruitment (Northwest Power Planning Council 2001c). Little LWD is present (TAG 2001, personal communication).

Pool Frequency

In 1981, pools comprised 27% to 37% of stream surface on this reach (USDA Soil Conservation Service *et al.* 1981a). In 1999, pools represented 2% to 4% of surface area at two sample sites on this reach. Riffles comprised 73% to 95% of stream surface area at these sites (Catts and Rabe 2000). Pools are rare in Alpowa Creek (Northwest Power Planning Council 2001c).

Pool Quality

Pools are generally small and shallow with little or no cover (Mendel 2001, personal communication).

Off-Channel Habitat

Channelization and removal of woody riparian vegetation have made off-channel habitat rare on Alpowa Creek (Northwest Power Planning Council 2001c).

Water Quality/Temperature

Total suspended solids (TSS) levels exceeded 80 mg/L twice on this reach from December 1998 to March 1999. The highest concentration reported was 181 mg/L on December 30, 1998. Water temperature (grab sample) exceeded 70 °F on this reach in June and August 1999. Temperatures exceeded 65 °F in August 2000 (Washington State University Center for Environmental Education 2001b, unpublished work). No recent daily minimum, maximum, and average water temperature data were available for Alpowa Creek. However, in 1981 temperatures exceeded 70 °F in late May, several days in June, and throughout August (Mendel and Taylor 1981).

Water Quantity/Dewatering

Springs provide perennial flow to Alpowa Creek (Northwest Power Planning Council 2001c).

Change in Flow Regime

Alpowa Creek is somewhat unique in the fact that the headwaters are not wooded like other streams in southeast Washington. The entire watershed is either grazed or farmed. The system has likely become more "flashy" because of these land uses (Mendel 2001, personal communication).

Biological Processes

Adult steelhead abundance is very low. Other anadromous species may have been present historically (Mendel 2001, personal communication).

Alpowa Creek (Stember Creek to mouth)

Habitat Ratings

Fish Passage

Pomeroy Conservation District and Wilson Banner Range installed an irrigation intake in 2000 to irrigate orchards on the farm. This eliminated the use of three concrete dams in the channel to divert water. The project was funded by the SRFB (Northwest Power Planning Council 2001c).

Screens and Diversions

Pomeroy Conservation District estimates that 10 surface water diversions are in use in the Alpowa Creek Watershed (Northwest Power Planning Council 2001c). The diversion installed in 2000 at Wilson Banner Ranch meets state and federal screening requirements (Mendel 2002a, personal communication). No information on screening compliance was available for the other diversions.

Riparian Condition

A 1981 survey of Alpowa Creek found 83% of this reach was heavily grazed. Trees were in "fair to poor" condition. Most trees were relicts with little potential for recolonization (USDA Soil Conservation Service *et al.* 1981a). Today immature alder, cottonwood, and willows 20 to 40-feet in height form a narrow, but nearly continuous buffer from Stember Creek downstream to Alpowa Ranch. The riparian buffer from Alpowa Ranch to the mouth is patchy, but some relatively large deciduous trees are present. It appeared that livestock was excluded from about 33 to 50% of the reach from Stember Creek to the mouth. The understory was not visible from U.S. Highway 12 (Kuttel 2001b). Pomeroy CD has enrolled 53 acres near the mouth of Stember Creek in the CREP (Bartels 2002, personal communication).

Streambank Condition

The 1981 survey of Alpowa Creek found 8% of banks on this reach eroding (USDA Soil Conservation Service *et al.* 1981a).

Floodplain Connectivity

Some small cobble berms are present on lower Alpowa Creek to reduce flooding (Mendel 2001, personal communication).

Width/Depth Ratio

Width/depth ratio during a 1981 survey was 24 (USDA Soil Conservation Service *et al.* 1981a).

Substrate Embeddedness

Gravel and rubble dominate substrate downstream from Pow Wah Kee Gulch. Embeddedness at this site was 50% with 100% of rock surfaces covered with fine sediment (Catts and Rabe 2000). Embeddedness in 1981 was nearly equivalent with a value of 46%. It appeared that the majority of fine sediment entering this reach of Alpowa Creek originated in gullies draining cropland (USDA Soil Conservation Service *et al.* 1981a).

Large Woody Debris

Destruction of woody riparian vegetation has led to low levels of large woody debris (Northwest Power Planning Council 2001c).

Pool Frequency

Pools are an infrequent occurrence on Alpowa Creek (Northwest Power Planning Council 2001c). In 1981 pools comprised 23% of stream area on this reach (USDA Soil Conservation Service *et al.* 1981a). Channelization and low large woody debris levels caused by riparian degradation are the likely cause of low pool frequencies (TAG 2001, personal communication).

Pool Quality

Pools are generally small and shallow with little or no cover (Mendel 2001, personal communication).

Off-Channel Habitat

Channelization and removal of woody riparian vegetation have made off-channel habitat rare on Alpowa Creek (Northwest Power Planning Council 2001c), but a few off-channel areas exist (Mendel 2001, personal communication).

Water Quality/Temperature

Total suspended solids (TSS) loads exceeded 80 mg/L on this reach four times from September 1998 to October 1999. The highest value measured during the sample period was 2,170 mg/L on January 15, 1999. High TSS levels generally coincided with peaks in stream discharge. Water temperature (grab sample) below Pow Wah Kee Gulch exceeded 70 °F from June through August 1999 and 65 °F in August 2000. (Washington State University Center for Environmental Education 2001b, unpublished work). Recent daily minimum, maximum, and average temperature data were not available for Alpowa Creek. However, in 1981 maximum water temperatures exceeded 80 °F from mid-July to late August (Mendel and Taylor 1981).

Water Quantity/Dewatering

Alpowa Creek is the only perennial stream in the watershed, although Stember Creek maintains surface flow during most years (Northwest Power Planning Council 2001c). Some portions of the channel have gone dry in past years (Mendel 2002a, personal communication). The low flow measured below Pow Wah Kee Gulch was 5.3 cfs in October 1999 and 5.6 cfs in July and

August 2000 (Washington State University Center for Environmental Education 2001b, unpublished work). Permits, claims, and certificates on file with WDOE identify a potential instantaneous withdrawal of 6.98 cfs of flow or 866.8 acre-feet per year of water from Alpowa Creek (Neve 2001, personal communication).

Change in Flow Regime

Farming and grazing throughout the entire watershed may have made the system more "flashy" (Mendel 2001, personal communication).

Biological Processes

Steelhead abundance is very low. Other anadromous species may have been present historically (Mendel 2001, personal communication).

Meadow Creek

Habitat Ratings

Fish Passage

Debris dams of tumble weed (Russian thistle) and fine sediment cause frequent blockages of steelhead passage. A woody riparian buffer would likely prevent the tumbleweeds from reaching the stream channel and therefore prevent formation of debris dams (Mendel 2001, personal communication). Three 2' high waterfalls without plunge pools were barriers from RM 7.2 to RM 8.3. Seven barriers were noted from the mouth to RM 1.8 on North Meadow Creek (Mendel 2001, unpublished work).

Screens and Diversions

No diversions were observed from RM 7.2 to RM 8.3 or RM 12.8 to RM 13.9. No diversions were observed from the mouth of North Meadow Creek to RM 1.8 (Mendel 2001, unpublished work).

Riparian Condition

Woody shrubs and a few scattered willows dominate riparian vegetation on Meadow Creek from the mouth upstream to Ben Day Creek (Kuttel 2001b). False Indigo (an introduced species) has taken over the riparian zone of Meadow Creek (TAG 2001, personal communication). Forbs were the dominant riparian vegetation from RM 7.2 to RM 8.3. Some grazed pasture and a few deciduous trees with an average height of 10' and maximum height of 27.5' were also present. The buffer averaged 7.5' in width and provided 17% shading (Mendel 2001, unpublished work). Cattle grazing and dryland farming are both practiced on the valley floor. Wheat is farmed to the edge of the terrace just downstream from the forks (Kuttel 2001b). Forbs and shrubs were the primary riparian vegetation from RM 12.8 to RM 13.9. The shrubs ranged from 4' to 7' tall and provided average shading of 21%. The buffer averaged 4' in width (Mendel 2001, unpublished work). Grasses, sedges, rushes, and cattails dominated the riparian zones of both forks of Meadow Creek. Small patches of mature deciduous trees were present at the end of the county road on South Meadow Creek and the lower half mile of North Meadow Creek (Kuttel 2001b). Grazed pasture, grasses and forbs, and some deciduous trees were present from the mouth of North Meadow Creek to RM 1.8. The buffer averaged 5' in width with trees 8' to 24' in height. Shading averaged 45% (Mendel 2001, unpublished work) (See Figure 18).


Figure 18. Riparian vegetation along lower Meadow Creek (about river mile 1). Photographed 9/26/2001

Streambank Condition

Incision of the mainstem of Meadow Creek begins about a mile above the mouth and abruptly ends at a feedlot near river mile four. A large portion of this incised reach is about 20 to 30 feet in depth and up to 100 feet wide (See Figure 19). Less severe incision up to about 10 feet deep is present from the forks downstream as far as can be seen from Guild City-Mayview Road. Neither of the forks appear to be incised (Kuttel 2001b). Banks were severely degraded from RM 7.2 to RM 8.3. An average of 60% of banks were actively eroding. Banks were moderately degraded from RM 12.8 to RM 13.9 with an average of 50% eroding banks. Moderate to severe bank degradation was present on North Meadow Creek from the mouth to RM 1.8. An average of 48% of banks were eroding (Mendel 2001, unpublished work).

Floodplain Connectivity

Channel incision up to 30 feet deep had led to abandonment of the historic floodplain. A new floodplain is forming in portions of the channel that have widened from a Rosgen “G” gully channel to an “F” channel. These new floodplains are far smaller than the terrace that formerly functioned as the floodplain (Kuttel 2001b). Portions of North Meadow Creek from the mouth to RM 1.8 had access to a floodplain (Mendel 2001, unpublished work) (See Figure 19).


Figure 19. Channel incision on lower Meadow Creek (about river mile 2). Photographed 9/26/2001.

Width/Depth Ratio

Width/depth ratio 18.6 from RM 7.2 to RM 8.3 and 15 from RM 12.8 to RM 13.9. The width/depth ratio of North Meadow Creek was 18.3 from the mouth to RM 1.8 (Mendel 2001, unpublished work).

Substrate Embeddedness

Mud was the dominant substrate from RM 7.2 to RM 8.3 and RM 12.8 to RM 13.9. Mud was also the dominant substrate in North Meadow Creek from the mouth to RM 1.8 (Mendel 2001, unpublished work).

Large Woody Debris

Woody debris was nearly non-existent from RM 7.2 to RM 8.3, RM 12.8 to RM 13.9, and on North Meadow Creek from the mouth to RM 1.8 (Mendel 2001, unpublished work).

Pool Frequency

Pool frequency was 15.5 per mile from RM 7.2 to RM 8.3 and 12 per mile from RM 12.8 to RM 13.9. North Meadow Creek has 2.2 pools per mile from the mouth to RM 1.8 (Mendel 2001, unpublished work).

Pool Quality

Riffles and runs dominated Meadow Creek (Mendel 2001, unpublished work).

Off-Channel Habitat

No side channels were observed on Meadow Creek from RM 7.2 to RM 8.3 or RM 12.8 to RM 13.9. No off-channel areas were found on North Meadow Creek from the mouth to RM 1.8

(Mendel 2001, unpublished work). Channel incision would greatly limit off-channel habitat in this system (Kuttel 2001b).

Water Quality/Temperature

Mean water temperatures occasionally exceeded 65 °F from July to mid-August 2001 at RM 0.4 and RM 5.6. Daily maximum temperatures exceeded 70 °F several times at RM 0.4, but rarely reached that level at RM 5.6 during the same time period. Mean temperatures at the Gould City Bridge (RM 13.9) reached 60 °F only twice from May to mid-July 2001. Daily maximum temperatures never reached 65 °F during that time period (Mendel 2001, unpublished work). Total suspended solids (TSS) levels during the 1964-65 floods were nearly double the 200,000 mg/L concentration measured on the Tucannon River (Esmaili and Associates 1982).

Water Quantity/Dewatering

April 2001 flow on Meadow Creek was 2.7 cfs. Flow in August 2001 was 2 cfs. North Meadow Creek carried 0.3 cfs in April 2001, but was too low to measure in August 2001 (Mendel 2001, personal communication).

Change in Flow Regime

No information on flow regime was available.

Biological Processes

Invasion of False Indigo in the riparian zone, depressed anadromous fish returns, and reduced beaver populations are the biological factors of concern on Meadow Creek (TAG 2001, personal communication).

North and South Deadman Creeks

Habitat Ratings

Fish Passage

Four barriers were identified on South Deadman Creek from RM 0.8 to RM 1.5. No descriptions were available. No barriers were noted on North Deadman Creek from RM 1.0 to RM 1.4 (Mendel 2001, unpublished work).

Screens and Diversions

No diversions were noted from RM 0.8 to RM 1.5 on South Deadman Creek or RM 1.0 to RM 1.4 on North Deadman Creek (Mendel 2001, unpublished work).

Riparian Condition

Mature deciduous dominated the lower ¼ mile of North Deadman Creek, but no new recruitment was evident. With the exception of a few scattered trees, little woody riparian vegetation was present up to a farmstead at the intersection of Guild City-Mayview and North Deadman Creek Roads. Tillage was practiced to the edge of the stream from this farmstead downstream to the buffer above the forks (Kuttel 2001b). Grazed pasture and small trees were the primary vegetation from RM 1.0 to RM 1.4 (portion of reach discussed above) on North Deadman Creek. The buffer averaged 11' in width with an average shading of only 0.7% (Mendel 2001, unpublished work). A large gallery of mature deciduous trees was present at the farmstead, but grazing was very heavy from the farmstead upstream to Kirby-Mayview Road. Sagebrush and sparse grass were the dominant vegetation. A very impressive collection of mature deciduous trees was located along North Deadman Creek from the Mayview Grange upstream to the vicinity of Chappell Hill Road. The surrounding area was in production of dryland crops, but a dense buffer was being maintained along this reach. This buffer may be a good example of the historic riparian plant community. Little or no woody riparian vegetation was present along South Deadman Creek, but a few mature deciduous trees were scattered along the stream adjacent to Guild City-Mayview Road (Kuttel 2001b). Forbs, grasses, sedges, and rushes were the primary riparian plants along South Deadman Creek from RM 0.8 to RM 1.5. The buffer averaged 4' in width with no shading (Mendel 2001, unpublished work) (See Figure 20).

Figure 20. South Deadman Creek downstream from South Deadman Road crossing. Photographed 9/26/2001.

Streambank Condition

Little channel incision was evident from nearby county roads, but some incision is likely present along the portion of North Deadman Creek with tillage practiced to the edge of the stream (Kuttel 2001b). Banks along North Deadman Creek from RM 1.0 to RM 1.4 were severely damaged by moderate to heavy livestock grazing. An average of 57% of banks were eroding (Mendel 2001, unpublished work). Cattle grazing further upstream has also likely caused considerable bank damage (Kuttel 2001b) (See Figure 21). Banks were relatively stable on South Deadman Creek from RM 0.8 to RM 1.5 with little or no evidence of livestock damage. An average of 13% of banks were eroding (Mendel 2001, unpublished work).


Figure 21. Feedlot along North Deadman Creek. Photographed 9/26/2001.

Floodplain Connectivity

The majority of South Deadman Creek from RM 0.8 to RM 1.5 did not have access to a floodplain. North Deadman Creek also lacks floodplain access from RM 1.0 to RM 1.4 (Mendel 2001, unpublished work).

Width/Depth Ratio

South Deadman Creek had a width/depth ratio of 5.6 from RM 0.8 to RM 1.5. The width/depth ratio of North Deadman Creek from RM 1.0 to RM 1.4 was 6.7 (Mendel 2001, unpublished work).

Substrate Embeddedness

Gravel and rubble were the dominant substrates in both forks of Deadman Creek. Embeddedness ranged from 10% to 33% in South Deadman Creek, while it was 26% in North Deadman Creek. A layer of fine sediment covered 100% of rock surfaces in both streams (Catts and Rabe 2000). Mendel (2001) found cobble and bedrock to be the dominant substrates on South Deadman Creek from RM 0.8 to RM 1.5. Embeddedness was generally >25%. Cobble was the dominant substrate in North Deadman Creek from RM 1.0 to RM 1.4. Embeddedness was generally >50% (Mendel 2001, unpublished work).

Large Woody Debris

No woody debris was present on South Deadman Creek from RM 0.8 to RM 1.5 or North Deadman Creek from RM 1.0 to RM 1.4 (Mendel 2001, unpublished work).

Pool Frequency

Pools comprised 20% of surface area on South Deadman Creek and 29% of surface area on North Deadman Creek (Catts and Rabe 2000). South Deadman Creek had 7 pools per mile from

RM 0.8 to RM 1.5. North Deadman Creek had no pools from RM 1.0 to RM 1.4 (Mendel 2001, unpublished work).

Pool Quality

Runs dominated the channel of South Deadman Creek from RM 0.8 to RM 1.5. Riffles dominated habitat on North Deadman Creek from RM 1.0 to RM 1.4 (Mendel 2001, unpublished work).

Off-Channel Habitat

No off-channel habitat was found from RM 0.8 to RM 1.5 on South Deadman Creek and North Deadman Creek from RM 1.0 to RM 1.4 (Mendel 2001, unpublished work).

Water Quality/Temperature

Total suspended solids (TSS) levels exceeded 80 mg/L four times on North Deadman Creek from February 1999 to March 2001. The highest value measured was 564 mg/L on October 2, 2000. South Deadman Creek TSS values exceeded 80 mg/L during the study three times. The highest value recorded was 238 mg/L on February 15, 2000. Water temperatures (grab sample) on North Deadman Creek exceeded 70 °F in June and August 1999, but never exceeded 65 °F in 2000. Temperatures on South Deadman Creek followed the same pattern in 1999, but reached 70 °F in August 2000 (Washington State University Center for Environmental Education 2001a, unpublished work). Recent daily minimum, maximum, and average water temperature data were not available for North and South Deadman Creeks.

Water Quantity/Dewatering

The high flow for South Deadman Creek in 1999 was 3.6 cfs in February, while the highest flow in 2000 was 27 cfs in late June. The minimum flows reported for South Deadman Creek were 0.4 cfs and 0.5 cfs in September 1999 and 2000 respectively. The high flow for North Deadman Creek in 1999 was 4.8 cfs in February, while the highest flow in 2000 was 31 cfs in late June. The minimum flows reported for North Deadman Creek were 1.9 cfs in November 1999 and 1.5 cfs in October 2000 (Washington State University Center for Environmental Education 2001a, unpublished work). Both North and South Deadman Creeks were still flowing in late September 2001. The wetted width of both streams was estimated at 12 to 18 inches (Kuttel 2001b). North Deadman Creek carried 3 cfs of flow in August 2001 while South Deadman Creek carried only 0.75 cfs (Mendel 2001, unpublished work).

Change in Flow Regime

No information on flow regime was available.

Biological Processes

Reduced levels of marine-derived nutrients contributed by anadromous fish (i.e. eggs, juveniles, and decomposing carcasses) likely limit productivity (Mendel 2002a, personal communication). The watershed appears to support a healthy beaver population (See the following section) (TAG 2001, personal communication).

Deadman Creek (Forks to mouth)

Habitat Ratings

Fish Passage

A straw bale dam constructed to pool water for irrigation and 11 beaver dams blocked passage on Deadman Creek in 2001 (Mendel 2001, personal communication). One beaver dam may be a barrier from RM 1.5 to RM 2.9. No barriers were found from RM 2.9 to RM 4.5. No barriers were observed from RM 8.2 to RM 9.2 (Mendel 2001, unpublished work).

Screens and Diversions

One diversion was noted from RM 1.5 to RM 2.9. No information on screening compliance was available. No diversions were noted from RM 2.9 to 4.5 or from RM 8.2 to RM 9.2 (Mendel 2001, unpublished work).

Riparian Condition

Grazing and mechanical or chemical removal of vegetation are responsible for degraded and/or denuded riparian areas along Deadman Creek (USDA Soil Conservation Service *et al.* 1981c, Northwest Power Planning Council 2001c). Alfalfa was grown to the edge of the stream in several places from the forks (RM 12.3) downstream to the Lower Deadman Road Bridge. Some mature deciduous trees were present, but the majority were growing up out of the incised channel. Scattered buffers (about one to two trees in width) of mature deciduous trees were scattered from the Lower Deadman Road bridge downstream to a wheat field farmed to the edge of the terrace (in the vicinity of Lynn Gulch) (Kuttel 2001b). Grasses, sedges, rushes, and a few small trees were the dominant riparian vegetation from RM 8.2 to RM 9.2. The buffer averaged 2.5' in width and provided 2.7% shading. Grasses, sedges, rushes, and shrubs were the primary riparian vegetation from RM 2.9 to RM 4.5. The buffer averaged 5.5' in width with a maximum height of 8.5'. Shade was almost non-existent (Mendel 2001, unpublished work). Alfalfa was grown from Ping Gulch (about RM 3) downstream to about one half mile above the mouth (Kuttel 2001b). Grasses, shrubs, and a few deciduous trees were the primary riparian vegetation from RM 1.5 to RM 2.9. The buffer averaged 12.5' in width and 6' in height with an average maximum height of 12'. Shading averaged 14% (Mendel 2001, unpublished work). A large forest of willows was present from the mouth of Deadman Creek upstream to Willow Gulch (Kuttel 2001b).

Streambank Condition

Incision 5 to 10-feet in depth began about one to two-miles below the forks. The incision deepened to about 20 to 30-feet at Lynn Gulch and gradually decreased to three to five-feet deep downstream at Ping Gulch (Kuttel 2001b). Banks showed moderate to severe livestock damage from RM 8.2 to RM 9.2. However, only an average of 17.5% of banks were eroding. Banks were severely damaged and oversteepened from RM 1.5 to RM 4.5. Average erosion was 15% from RM 2.9 to RM 4.5. Some livestock damage was evident (Mendel 2001, unpublished work).

Floodplain Connectivity

The historic floodplain has been abandoned on the incised reaches. Although it could not be confirmed, a new floodplain is likely forming in the bottom of the "F" channel. The majority of the terrace is used for agricultural production of wheat and alfalfa (Kuttel 2001b). The stream has access to the floodplain from RM 8.2 to RM 9.2. The floodplain is accessible from RM 2.9

to RM 4.5. Little floodplain connectivity was present from RM 1.5 to RM 2.9 (Mendel 2001, unpublished work).

Width/Depth Ratio

The width/depth ratio was 9.2 from RM 8.2 to RM 9.2 and RM 1.5 to RM 2.9. Width/depth ratio from RM 2.9 to RM 4.5 was 4.6 (Mendel 2001, unpublished work).

Substrate Embeddedness

As of 1984, sheet and rill erosion of cropland carried 66,000 tons of fine sediment per year to Deadman Creek (USDA Soil Conservation Service *et al.* 1984). Cobble and gravel were the dominant substrate from RM 8.2 to RM 9.2. Mud and cobble were the dominant substrate from RM 1.5 to RM 4.5. Embeddedness was generally >50% (Mendel 2001, unpublished work).

Large Woody Debris

Little woody debris was present from RM 8.2 to RM 9.2. Woody debris was rare or absent from RM 1.5 to RM 4.5 (Mendel 2001, unpublished work).

Pool Frequency

Deadman Creek had 4 pools per mile from RM 8.2 to RM 9.2. Pool frequency from RM 2.9 to RM 4.5 was 6.3 pools per mile. No pools were found from RM 1.5 to RM 2.9 (Mendel 2001, unpublished work).

Pool Quality

Riffles and runs dominated the channel from RM 8.2 to RM 9.2, RM 2.9 to RM 4.5, and RM 1.5 to RM 2.9. Pools were generally small with little cover. Boulders and turbulence were the primary instream cover (Mendel 2001, unpublished work).

Off-Channel Habitat

Numerous side channels were present from RM 8.2 to RM 9.2. No off-channel habitat was encountered from RM 2.9 to RM 4.5. Some side channel habitat was present from RM 1.5 to RM 2.9 (Mendel 2001, unpublished work).

Water Quality/Temperature

Total suspended sediment (TSS) levels during the 1964-65 floods were nearly double the 200,000 mg/L concentration measured on the Tucannon River (Esmaili and Associates 1982). Total suspended solids concentrations exceeded 80 mg/L five times from February 1999 to March 2001. The highest value measured was 11,480 mg/L on October 2, 2000. Water temperature (grab sample) exceeded 70 °F in June and August 1999 and August 2000 (Washington State University Center for Environmental Education 2001a, unpublished work). Mean water temperatures at RM 1.6 often exceeded 70 °F and daily maximum temperatures often came close to or exceeded 75 °F from mid-June to mid-August 2001. Average water temperatures at RM 9.2 often exceeded 65 °F, but daily maximums rarely exceeded 70 °F from June to mid-August 2001 (Mendel 2001, unpublished work).

Water Quantity/Dewatering

The highest flows measured in Deadman Creek were 13.6 cfs in mid-February 1999 and 18.1 cfs in mid-March 2000. Low flows were 2.4 cfs and 1.3 cfs in mid-August 1999 and 2000 respectively (Washington State University Center for Environmental Education 2001a, unpublished work). Flow on lower Deadman Creek was 3.5 cfs in July 2001 and 4.0 cfs in August 2001. Upper Deadman Creek carried 2.55 cfs of flow in July 2001 (Mendel 2001, personal communication). Streamflow appears adequate to allow salmonid migration through Deadman Creek during the summer months (Northwest Power Planning Council 2001c). The wetted width of Deadman Creek was estimated at three to five-feet in late September 2001 (Kuttel 2001b). The stream gets very low in the summer, but no dry reaches have been noted (Mendel 2001, personal communication). Permits, claims, and certificates on file with WDOE identify a potential instantaneous withdrawal of 11.73 cfs of flow or 3,626.95 acre-feet per year of water from Deadman Creek (Neve 2001, personal communication).

Change in Flow Regime

No information on flow regime was available.

Biological Processes

Reduced levels of marine-derived nutrients contributed by anadromous fish (i.e. eggs, juveniles, and decomposing carcasses) likely limit productivity (Mendel 2002a, personal communication). The stream appears to support a robust beaver population as evidenced by the 11 dams discussed previously (TAG 2001, personal communication).

ALPOWA-DEADMAN SUBBASIN RECOMMENDATIONS

Protect the remaining functional riparian buffers on Alpowa and Deadman Creeks, including the mature stand along Alpowa Creek above Stember Creek, the forest that is regrowing from Stember Creek downstream to Alpowa Ranch, and the remaining patches of riparian forest along Deadman Creek.

Reestablish riparian forest buffers along Alpowa, Deadman, and Meadow Creeks. Restoration of riparian buffers on Alpowa Creek upstream from (and along) Stember Creek is the highest priority for riparian plantings on Alpowa Creek. Restore connectivity between the remaining patches of riparian forest on Deadman Creek. The entire Meadow Creek system is in need of riparian plantings.

Practice proper riparian vegetation management to ensure healthy vigorous plant growth of woody vegetation and natural regeneration. Best management practices (BMPs) could include, but are not limited to: limited riparian "flash grazing," pasture rotation, fencing livestock out of streams and riparian areas, and development of off-site watering facilities.

Continue to reduce fine sediment deposition throughout the subbasin by implementation of no-till/direct seed farming methods and riparian buffers through CRP, CREP, and SRFB programs.

Reduce summer stream temperatures and improve channel and bank stability through restoration of riparian forest buffers.

Inventory surface water diversions and evaluate compliance with state and NMFS screening requirements. Screen diversions where necessary.

In the short term, increase complexity of instream habitat through installation of large woody debris, creation of pools in limited locations selected by technical experts. Reliance on instream projects should be minimized since they largely treat symptoms, rather than addressing the root cause(s) of habitat degradation.

Enforce existing land use regulations including Critical Area Ordinances, Shoreline Management Act, and the Growth Management Act.

Inventory habitat conditions as well as fish presence and relative abundance on subbasin streams every five years to fill data gaps and monitor success of habitat restoration projects. Conduct continuous monitoring of water quality parameters such as water temperature and total suspended solids.

TUCANNON SUBBASIN HABITAT LIMITING FACTORS

Tucannon Subbasin Description

The Tucannon Subbasin encompasses the entire Tucannon watershed and all tributaries (approximately 502 square miles). The stream system originates high in the northeast portion of the Blue Mountains at an elevation of 6,234 feet (at Diamond Peak) and terminates at the Snake River (RM 62) at about 540 feet elevation (See Map 15). Dryland agriculture and livestock grazing are the dominant land uses in mid-elevation upland areas, while forestry, recreation and grazing are the primary land uses at higher elevations. The subbasin is characterized by deep v-shaped valleys in headwater areas gradually widening into comparatively broad valley bottoms on the lower mainstem of the Tucannon River and Pataha Creek. The topography is the result of folding and faulting of extensive deposits of Columbia River Basalts. Highly erodible loess soils on the plateau tops support extensive acreages of dryland farming. As of October 2001, 21,047 acres (30% of cropland) in the Tucannon Watershed were enrolled in the CRP (Northwest Power Planning Council 2001e). There is generally a large difference in elevation between the valley bottom of the drainage network and the surrounding plateaus. Intermittent and/or ephemeral streams are present throughout the watershed. Under typical conditions these streams do not convey much water, but during thunderstorms or rain-on–snow events they are capable of carrying immense debris torrents into the Tucannon River. The sediment moving capacity of these small streams is easily seen in the extensive alluvial fans deposited at their mouths. Major storms often carry immense fine sediment loads to the Tucannon River. The 1964-65 floods produced an extreme example of high fine sediment loads with a total suspended solids concentration of 200,000 mg/L (Esmaili and Associates 1982). Habitat conditions in the Tucannon Subbasin range from generally fair to good in the Tucannon Drainage to generally poor in the Pataha Drainage (See Table 10).

Salmonid bearing streams in the subbasin include Bear Creek, Sheep Creek, Cold Creek, Panjab Creek, Turkey Creek, Meadow Creek, Little Tucannon River, Hixon Creek, Cummings Creek, Tumalum Creek, Pataha Creek, and the mainstem Tucannon River. Summer steelhead/rainbow, spring chinook, fall chinook, resident rainbow trout, and bull trout are currently present. Summer steelhead/rainbow are presumed to be present in Kellogg and Smith Hollow Creeks. Coho were historically present (See Appendix B).

Tucannon River (Headwaters to Panjab Creek) Including Bear, Cold, Sheep, and Panjab Creeks

Habitat Ratings

Fish Passage

Three falls are present on Bear Creek from the mouth upstream to RM 3.0 (Forest Service 1992a, unpublished work). A 10' high falls at RM 2.0 blocks anadromy on Cold Creek (Forest Service 1992b, unpublished work). A 12' high logjam at RM 0.3 on Meadow Creek may have been a barrier in 1992 (Forest Service 1992f, unpublished work), but it is apparently no longer present

(Mendel 2002a, personal communication). A 25' high falls at RM 0.5 on Sheep Creek blocks upstream fish passage (Forest Service 1992j, unpublished work).

Screens and Diversions

No irrigation diversions are in use on these stream reaches (TAG 2001, personal communication).

Riparian Condition

Riparian vegetation was assessed in 1994. A mixture of grand fir and alder in the small tree/small pole size class dominated riparian vegetation on this reach of the Tucannon River. Canopy cover averaged 54% (See Figure 22). The Bear Creek riparian zone was dominated by Douglas-fir and Pacific yew and provided an average of 21% canopy cover. Riparian vegetation along the lower 0.5 mile of Sheep Creek was dominated by grand fir and alder that provided an average canopy cover of 20%. The riparian zone along Panjab, Meadow, and Turkey Creeks was dominated by large grand fir and alder with some maple on upper Panjab Creek. Average canopy cover was 56%, 62%, and 48% for Panjab, Meadow, and Turkey Creeks respectively (Columbia Conservation District 1997). All of Panjab Creek from Meadow Creek (RM 1.9) upstream is located within the Wenaha-Tucannon Wilderness Area. No grazing has occurred in the Wilderness portion of Panjab Creek since the early 1950s and logging last took place in 1978. A vast network of trails is heavily used by pack animals (Forest Service 1992h, unpublished work). The lower end of Meadow Creek was part of the Upper Tucannon grazing allotment, which averaged 70 head of cattle. Damage caused by grazing was minimal during 1992 surveys (Forest Service 1992f, unpublished work), the last year grazing was allowed (Groat 2001, personal communication). Recreation is a major activity on public lands in the Tucannon Watershed. Visitors spend an estimated 400,000 "Recreation Visitor Days" per year on Forest Service lands (Forest Service 1994). Twenty-seven campgrounds, 16 on USFS lands, and 11 on the Wooten Wildlife Area were located along the Tucannon River. Riparian vegetation was damaged or cleared to make room for campsites and parking (Johnson 1995). Logs and dead wood were cut for firewood, while small brush was cut for roasting sticks. Trees were damaged by being used to hang lanterns and other items and as stock hitching posts (Columbia Conservation District 1997). Some of the campgrounds were either eliminated or relocated to repair the existing riparian damage and prevent future damage (Johnson 1995). As of 2001, WDFW maintained seven campgrounds and the Forest Service managed five campgrounds (Northwest Power Planning Council 2001e).

Figure 22. Tucannon River riparian vegetation at Sheep Creek. Photographed 6/14/2001.

Streambank Condition

Bank cover on Sheep Creek, Cold Creek, Panjab Creek, Meadow Creek, and Turkey Creek ranged from 50 to 75% when surveyed in 1992 (Forest Service 1992b, unpublished work, Forest Service 1992f, unpublished work, Forest Service 1992h, unpublished work, Forest Service 1992j, unpublished work, Forest Service 1992k, unpublished work).

Floodplain Connectivity

All stream reaches in this area flow down relatively high gradients where floodplains would be expected to be naturally small or nonexistent. No diking or other channelization activities are known to have taken place on these stream reaches (TAG 2001, personal communication).

Width/Depth Ratio

Data from summer 1986 WDFW stream surveys were used to calculate a mean width/depth ratio of 20.7 on Panjab Creek(Schuck *et al.* 1988). In 1992, average width/depth ratios for Cold, Panjab, Meadow and Turkey Creeks were 3.6, 5.6, 5.2, and 8.2 respectively. No information was available for Bear and Sheep Creeks or the Tucannon River (Forest Service 1998, unpublished work).

Substrate Embeddedness

Embeddedness on Bear, Sheep, and Cold Creeks was 26%, 16%, and 18% respectively in 1992. Conditions were worse on Panjab and Turkey Creeks with average values of 35% and 49% respectively. Embeddedness on Meadow Creek was 17% in 1992. Embeddedness averaged 16% on the Tucannon in 1992 (Forest Service 1998, unpublished work). Only two square-yards of spawning gravel were noted on Cold Creek from the mouth to RM 2.0 (Forest Service 1992b, unpublished work). The 1996-97 floods flushed out fine sediment, reducing substrate embeddedness throughout the upper portion of the Tucannon Watershed (Groat 2001, personal communication).

Large Woody Debris

Bear, Sheep, and Cold Creeks all had abundant levels of LWD in 1992 with 83, 298, and 238 pieces per mile respectively. LWD was also plentiful on Panjab Creek (212 pieces per mile), Turkey Creek (232 pieces per mile), and Meadow Creek (246 pieces per mile). The Tucannon River had 52 pieces of LWD per mile in 1997 (Forest Service 1998, unpublished work) (See Figure 23).

Figure 23. Log in Sheep Creek stabilizing streambed. Photographed 6/14/2001.

Pool Frequency

The following pool frequencies per mile were inventoried in 1992: Bear Creek (9.7) (Forest Service 1992a, unpublished work), Sheep Creek (14, 3.5% stream surface area) (Forest Service 1992j, unpublished work), Cold Creek (3.5) (Forest Service 1992b, unpublished work), Panjab Creek (13.2, 4.3% stream surface area) (Forest Service 1992h, unpublished work), Turkey Creek (11, 2.5% stream surface area) (Forest Service 1992k, unpublished work), Meadow Creek (7) (Forest Service 1992f, unpublished work). In 1992, this reach of the Tucannon River had 12 pools per mile (Columbia Conservation District 1997).

Pool Quality

Mean residual pool depth on Bear Creek was 1.9 feet when surveyed in 1992 (Forest Service 1992a, unpublished work). Residual pool depth on Cold Creek averaged 1.1 feet in 1992 (Forest Service 1992b, unpublished work). Pools on Meadow Creek were shallow with an average residual depth of 0.9 feet in 1992 (Forest Service 1992f, unpublished work). Residual pool depth on Panjab Creek was 1.2' in 1992 (Forest Service 1992h, unpublished work). Pools on Sheep Creek were relatively deep with a residual depth of 2.6' in 1992 (Forest Service 1992j, unpublished work). Large woody debris and overhanging vegetation provided plentiful fish cover on Turkey Creek (Forest Service 1992k, unpublished work).

Off-Channel Habitat

Off-channel habitat is rare or absent on these stream reaches because of the relatively steep gradients (TAG 2001, personal communication).

Water Quality/Temperature

Average seven-day maximum summer water temperatures for 1992 through 2000 on Bear, Sheep, Panjab, and Meadow Creeks and the Tucannon River above Bear Creek were 60 °F, 52 °F, 60 °F, 56 °F, and 57 °F respectively (Forest Service (USDA) 2001, unpublished work). In the summer of 2000 maximum water temperatures rarely reached 60 °F in the Tucannon River at Panjab Creek (Snake River Lab 2001). Summer 2001 mean water temperatures never exceeded 54 °F at Lady Bug Flat and exceeded 55 °F on only two occasions downstream at the Panjab Bridge. Maximum water temperatures at Lady Bug Flat never exceeded 57 °F, while they exceeded 60 °F twice at the Panjab Bridge (Bumgarner 2002).

Water Quantity/Dewatering

Human activities have not reduced water quantity on these stream reaches (TAG 2001, personal communication). WDFW measured flows of 2.9 cfs (trail #3127) and 6.7 cfs (0.9 miles above Camp 13 Bridge) on Panjab Creek in early August 1986 (Schuck *et al.* 1988).

Change in Flow Regime

No change in flow regime is known to have occurred (TAG 2001, personal communication).

Biological Processes

Reduced levels of marine-derived nutrients contributed by anadromous fish (i.e. eggs, juveniles, and decomposing carcasses) likely limit productivity. For example, as recently as the late 1950s, about 5,000 spring chinook returned to the Tucannon River System. At an average weight of 10-pounds per fish, a total of 50,000-pounds of carcasses would have been present following spawning. In 1995, a record low return of 54 spring chinook would have provided only 540-pounds of carcasses. This example doesn't consider the historic nutrient contribution provided by coho that were once abundant (Mendel 2002a, personal communication), but have been extinct since 1929 (Parkhurst 1950).

Tucannon River (Panjab Creek to Marengo) Including Little Tucannon River, Hixon Creek, Cummings Creek, and Tumalum Creek

Habitat Ratings

Fish Passage

A culvert under Forest Road 47 near the mouth of the Little Tucannon River is passable (Forest Service 1992e, unpublished work). No fish passage barriers were observed during 1992 surveys of Cummings Creek (Forest Service 1992d, unpublished work). Two culverts on Hixon Creek within the Camp Wooten Environmental Learning Center may be barriers (Boe 2001, personal communication). Large sections of Tumalum Creek go subsurface during the summer months, causing a potential passage problem. The dam at the Tucannon Hatchery has a new modern ladder. The ladder is checked frequently to make adjustments according to flow conditions, but the dam may delay passage at some flows (Mendel 2002a, personal communication).

Screens and Diversions

No irrigation diversions are known to be in use on the Little Tucannon River, Cummings Creek, or Tumalum Creek (TAG 2001, personal communication). State-of-the-art screens were installed on many diversions along the Tucannon from 1990 to 1992 (Johnson 1995). However, it is not known if these screens are still functioning following the 1996-97 floods or if the screens meet current state and federal screening regulations (TAG 2001, personal communication). Six man-made lakes (Curl, Big Four, Beaver, Watson, Deer, and Rainbow Lakes) divert water from the Tucannon River. The Tucannon Hatchery is supplied from the Rainbow Lake diversion. All six diversions are screened to year 2001 screening criteria. Several small pump diversions are likely in use on this reach, but no quantitative information was available (Mendel 2002a, personal communication).

Riparian Condition

Riparian vegetation along this reach of the Tucannon was severely damaged in the 1964-65 floods (Esmaili and Associates 1982). The following assessment was made in 1994. Riparian vegetation on this reach of the Tucannon River was dominated by deciduous trees, primarily alder and cottonwood. Recreation is a major activity on public lands in the Tucannon Watershed. Visitors spend an estimated 400,000 "Recreation Visitor Days" per year on Forest Service lands (Forest Service 1994). Twenty-seven campgrounds, 16 on USFS lands, and 11 on the Wooten Wildlife Area were located along the Tucannon River. Riparian vegetation was damaged or cleared to make room for campsites and parking (Johnson 1995). Logs and dead wood were cut for firewood, while small brush was cut for roasting sticks. Trees were damaged by being used to hang lanterns and other items and as stock hitching posts (Columbia Conservation District 1997). Some of the campgrounds were either eliminated or relocated to repair the existing riparian damage and prevent future damage (Johnson 1995). As of 2001, WDFW maintained seven campgrounds and the Forest Service managed five campgrounds (Northwest Power Planning Council 2001e). From Tumalum Creek upstream to Panjab Creek mature cottonwoods and alders formed the overstory with an understory of immature alders and cottonwoods. Small alders and cottonwoods interspersed with mature trees dominated from Tumalum Creek downstream to Marengo. Canopy cover averaged 30% on the Tucannon. The Little Tucannon River riparian zone was dominated by mature grand fir and alder that produced an average canopy cover of 85%. Cummings Creek had an extensive riparian buffer. The lower six miles were dominated by large cottonwoods and alders and provided 90% canopy cover. From RM 6.2 upstream the riparian zone was a mixture of coniferous trees in the small tree/pole size class, providing a canopy cover of 44% (Columbia Conservation District 1997). Bank cover on the Little Tucannon River and Cummings Creek ranged from 50 to 75% when surveyed in 1992 (Forest Service 1992d, unpublished work, Forest Service 1992e, unpublished work). Grazing was evident along the entire length of Cummings Creek, but no damage was evident (Forest Service 1992d, unpublished work). The Garfield County portion of upper Tumalum Creek had a riparian zone dominated by grand fir and alder with a grass/forb understory. Canopy cover for this reach averaged 66% (Columbia Conservation District 1997). The Cummings Creek fire in 1961 burned the entire canyons of Cummings and Tumalum Creeks (Forest Service 1993g, unpublished work). Little vegetation was left to collect water and stabilize soil and streambanks when the 1964 flood occurred. Both streams were extensively damaged by the flood (Groat 2001, personal communication).

Streambank Condition

Bank stability on this reach of the Tucannon River was described as "poor" (Northwest Power Planning Council 2001e). Camp Wooten is protected by a rip rapped dike (Army Corps of Engineers 2001). The Tucannon Hatchery is protected by a rip rapped bank (Mendel 2002a, personal communication). From Bridge 14 (RM 32) downstream to Marengo banks are almost entirely armored (Kelley and Associates 1982).

Floodplain Connectivity

Floodplain connectivity is restricted by dikes and levees on an estimated 13% of Tucannon streambanks upstream from Cummings Creek. The USACE completed 1,900 feet of levee (700 feet rip rapped) in December 1970 to protect Camp Wooten (Army Corps of Engineers 2001). The river has access to the floodplain on the majority of this reach, but riparian vegetation is degraded and substantial open areas are present (Northwest Power Planning Council 2001e). The floodplain width of Cummings Creek ranged from 15 to 390 feet (Forest Service 1992d, unpublished work).

Width/Depth Ratio

Average width/depth ratios for the Little Tucannon River (1992), Cummings Creek (1992) and Tumalum Creek (1993) on USFS lands were 8, 10.7, and 10.9 respectively (Forest Service 1998, unpublished work).

Substrate Embeddedness

Embeddedness levels in the Little Tucannon River (1996), Cummings Creek (1992) and Tumalum Creek (1993) on USFS lands averaged 16%, 11% to <35%, and 32% respectively (Cummings Creek values include measurements collected on state land) (Forest Service 1998, unpublished work). No spawning gravel was noted on the Little Tucannon River (Forest Service 1992e, unpublished work).

Large Woody Debris

Large wood was plentiful in the Little Tucannon River in both 1992 and 1996 with average values of 110 and 127 pieces per mile respectively (Forest Service 1998, unpublished work). LWD was also abundant in Cummings Creek (1992) with an average of 70 pieces per mile (Forest Service 1992d, unpublished work). Tumalum Creek (1993) had moderate levels of LWD with an average of 18 pieces per mile (Forest Service 1998, unpublished work). All inventoried reaches are located on USFS lands with the exception of lower Cummings Creek.

Pool Frequency

The increased large wood load observed in the Little Tucannon River from 1992 to 1996 appears to coincide with an increase in pool frequency from 20 pools per mile in 1992 to 29 pools per mile in 1996. Although LWD was less common on Tumalum Creek, more pools were found on this stream than Cummings Creek. In 1993, Tumalum Creek had 11 pools per mile, while Cummings Creek had an average of 7 pools per mile in 1992. All reaches of these tributaries are located on USFS lands with the exception of lower Cummings Creek which is located on state lands (Forest Service 1998, unpublished work). Pools comprised about 4% of stream surface area on this reach of the Tucannon when inventoried in 1994. Large pools (≥ 3' deep with ≥ 25 yd^2 surface area) occurred at an average frequency of 8 pools per mile, while 21 small pools (≥ 0.5' deep with ≥ 1 ft^2 surface area) per mile were found (Columbia Conservation District 1997).

Pool Quality

Man made pools on Cummings Creek created "excellent" fish habitat when observed in the summer of 1992 (Forest Service 1992d, unpublished work). Nineteen man made pools were counted from the mouth of the Little Tucannon River upstream to RM 3.75 in the summer of 1992. Average residual pool depth was 0.9' (Forest Service 1992e, unpublished work). An average of 20% of large pools and 7% of small pools on this reach of the Tucannon were associated with large woody debris (Columbia Conservation District 1997).

Off-Channel Habitat

Portions of the channel are braided, providing seasonal rearing habitat, but these areas are subject to high stream flows during flooding (Mendel 2002a, personal communication).

Water Quality/Temperature

Dissolved oxygen levels upstream from Marengo were generally high enough to support salmonid populations. August water temperatures from Bridge 12 (RM 29.4) downstream to the mouth were high enough to stress juvenile salmonids. Few young of the year steelhead, no steelhead yearlings, and no salmon were captured (Kelley and Associates 1982). The average seven-day maximum summer water temperature from 1992 to 2000 on the Little Tucannon River and Cummings Creek was 59 °F for both streams. Average seven-day maximum temperature on Hixon Creek was 56 °F from 1997 to 2000. Temperatures on the Tucannon were warmer with a seven-day average maximum (1987 to 1990) of 66.5 °F (Forest Service (USDA) 2001, unpublished work). Maximum summer water temperatures during 1999 and 2000 on this reach of the Tucannon rarely reached 65 °F at Big Four Lake. Temperatures exceeded 65 °F several times downstream at Beaver-Watson Lake. Maximum temperatures at Cummings Creek exceeded 60 °F only a few times in 1999, but exceeded 65 °F many times in 2000. Maximum temperatures at Bridge 14 reached 80 °F in 1999, but only occasionally exceeded 70 °F in 2000 (Snake River Lab 2001). Maximum summer 2001 water temperatures at the Little Tucannon River exceeded 60 °F on numerous occasions, but approached 65 °F only twice. Mean temperatures were often greater than 55 °F. Temperatures downstream at Camp Wooten were similar. Mean water temperatures at Big Four Lake reached 60 °F on several occasions with maximum temperatures often approaching or exceeding 65 °F. Mean temperatures at Cummings

Creek frequently exceeded 60 °F with maximum temperatures frequently greater than 65 °F and occasionally approaching 70 °F (Bumgarner 2002).

Water Quantity/Dewatering

The middle and lower reaches of Tumalum Creek are intermittent (Forest Service 1993g, unpublished work). The majority of landowners on the lower 30 miles of the Tucannon obtain water for summer irrigation. In the past low wing dams and permanent low-head dams were used to divert surface water to sprinkler systems or irrigation ditches. The diversions did not appear to diminish streamflow in a biologically significant manner (Kelley and Associates 1982). The majority of diversions were converted to pump intakes by the early 1990s (Johnson 1995). The Washington Department of Ecology (WDOE) has issued 193 cfs of surface water and 35 cfs of ground water claims and rights in the Tucannon Watershed. The combined total (228 cfs) is greater than the average annual flow of the river. All surface water rights issued since 1972 were conditioned to a 50 cfs minimum flow measured at the Snake River. The Tucannon is closed to further appropriations above Cummings Creek (Covert *et al.* 1995). Many of these water rights and claims are "paper rights" that are not being exercised (Ducharme 2002, personal communication).

Change in Flow Regime

From 1960 to 1990, the seven-day low flow on the Tucannon fell below the 65 cfs minimum flow at the Starbuck gage nearly every year with the exception of several years in the early 1970s. In 1960, flows fell below the 65 cfs target for about 30 days. By 1990, flows were lower than 65 cfs for more than 60 days. Average annual flows appear to have declined from 185 cfs in 1960 to 148 cfs in 1990 (-37 cfs) (Covert *et al.* 1995). No analysis was performed to determine the cause of the apparent decline in average annual flow. For all practical purposes the Tucannon River is closed to further appropriations (Ducharme 2002, personal communication).

Biological Processes

Reduced levels of marine-derived nutrients contributed by anadromous fish (i.e. eggs, juveniles, and decomposing carcasses) likely limit productivity. For example, as recently as the late 1950s, about 5,000 spring chinook returned to the Tucannon River System. At an average weight of 10-pounds per fish, a total of 50,000-pounds of carcasses would have been present following spawning. In 1995, a record low return of 54 spring chinook would have provided only 540-pounds of carcasses. This example doesn't consider the historic nutrient contribution provided by coho that were once abundant (Mendel 2002a, personal communication), but have been extinct since 1929 (Parkhurst 1950).

Tucannon River (Marengo to U.S. Highway 12)

Habitat Ratings

Fish Passage

De Ruwe Falls, located just upstream from U.S. Highway 12 may be a barrier at some flows (Mendel 2002a, personal communication).

Screens and Diversions

State-of-the-art screens were installed on many diversions along the Tucannon from 1990 to 1992 (Johnson 1995). However, it is not known if these screens are still functioning following the 1996-97 floods or if the screens meet current state and federal screening regulations. The number of diversions currently in use is not known (TAG 2001, personal communication).

Riparian Condition

Deciduous trees dominated the riparian zone on this reach of the Tucannon. Large alders and cottonwoods provided an average canopy cover of 43% in 1994 (Columbia Conservation District 1997). Much of the loss of riparian vegetation above Willow Creek appeared to be related to floods following 1964. However, conversion of riparian forests to irrigated fields and pastures also played a role. Between 1937 and 1964, 33% of the riparian woodland upstream from Pataha Creek was converted to fields, farmsteads, and other uses. This likely contributed to the extensive damage caused by the 1964-65 floods (Esmaili and Associates 1982). Significant acreages along this reach have been enrolled in the CREP. If the plantings are successful, riparian conditions should improve (TAG 2002, personal communication).

Streambank Condition

Increased magnitude and duration of peak flows, increased width caused by destruction of riparian vegetation, and increased coarse sediment loads from eroding streambanks caused the channel alterations of the Tucannon. Most channel changes on the Tucannon below Marengo predated the floods of the 1960s and 70s (Esmaili and Associates 1982).

Floodplain Connectivity

Following the 1964-65 floods the SCS and the USACE installed up to 40,000 feet of riprapped levees along the Tucannon, while the state, county, and private parties installed between 20,000 and 40,000 additional feet of levees. Much of the construction took place following the 1969 storms because heavy equipment was available during construction of dams on the lower Snake River. Each road or rail crossing of the Tucannon typically consists of a bridge and causeway that often extends the full width of the valley floor. These structures alter the channel for several hundred feet upstream and downstream from the crossing and likely contribute to maintenance of the braided channel form (Esmaili and Associates 1982). Some dikes were destroyed in the 1996-97 floods (Ducharme 2002, personal communication).

Width/Depth Ratio

No information was available.

Substrate Embeddedness

The bed of the Tucannon River becomes mobilized at flows of 250 to 300 cfs (Esmaili and Associates 1982). Following the 1996-97 floods (5,580 cfs) the Tucannon substrate was definitely not embedded with fine sediment (Southerland 2001, personal communication).

Large Woody Debris

Large woody debris is much less abundant than it was historically (Esmaili and Associates 1982).

Pool Frequency

In 1994, pools occupied about 7% of stream surface area on this reach. Large pools (≥ 3' deep with ≥ 25 yd^2 surface area) occurred at an average frequency of 11 pools per mile, while 46 small pools (≥ 0.5' deep with ≥ 1 ft^2 surface area) per mile were found (Columbia Conservation District 1997).

Pool Quality

An average of 40% of large pools and 35% of small pools on this reach of the Tucannon were associated with large woody debris (Columbia Conservation District 1997).

Off-Channel Habitat

Off-channel habitat is limited by dikes, but some is present. These areas are generally side channels that provide seasonal refuge during low to moderate flows, but are subject to high velocity during flood flows (Mendel 2002a, personal communication).

Water Quality/Temperature

High summer water temperatures on the lower 32 miles of the Tucannon River are believed by Kelley and Associates (1982) to be an unnatural condition initiated by the destruction of riparian vegetation during the 1964-65 floods. Subsequent floods and channelization have increased the severity of the problem. Dissolved oxygen levels at some sites on this reach were low enough to preclude survival of juvenile salmonids. August water temperatures on this reach were high enough to stress juvenile salmonids. Few young of the year steelhead, no yearlings, and no salmon were captured (Kelley and Associates 1982). Although summer water temperatures are still above desired levels, salmonids have been observed during the summer months (Mendel 2002a, personal communication). Summer of 1999 maximum water temperatures of the Tucannon at Marengo often approached 70 °F and occasionally exceeded this level. Year 2000 temperatures appeared to be even warmer with maximum temperatures over 70 °F from mid-to late July, but data collection stopped in August. Maximum water temperatures at Enrich Bridge (RM 17.4) frequently exceeded 70 °F in both 1999 and 2000 (Snake River Lab 2001). Mean summer 2001 water temperatures at the Marengo Bridge often exceeded 65 °F with maximums frequently greater than 70 °F. Mean temperatures at King Grade frequently exceeded 65 °F and approached 70 °F on several occasions. Maximum temperatures often exceeded 70 °F and were greater than 75 °F for two days. Mean temperatures at the U.S. Highway 12 Bridge frequently exceeded 70 °F with maximums often exceeding 75 °F (Bumgarner 2002).

Water Quantity/Dewatering

The majority of landowners on the lower 30 miles of the Tucannon obtain water for summer irrigation. In the past low wing dams and permanent low-head dams were used to divert surface water to sprinkler systems or irrigation ditches. The diversions did not appear to diminish streamflow in a biologically significant manner (Kelley and Associates 1982). The majority of diversions were converted to pump intakes by 1980 (Johnson 1995). The Washington Department of Ecology (WDOE) has issued 193 cfs of surface water and 35 cfs of ground water claims and rights in the Tucannon Watershed. The combined total (228 cfs) is greater than the average annual flow of the river. All surface water rights issued since 1972 were conditioned to a 50 cfs minimum flow measured at the Snake River. The Tucannon is closed to further appropriations above Cummings Creek (Covert *et al.* 1995). Many of these water rights and claims are "paper rights" that are not being exercised (Ducharme 2002, personal communication).

Change in Flow Regime

From 1960 to 1990, the seven-day low flow on the Tucannon fell below the 65 cfs minimum flow at the Starbuck gage nearly every year with the exception of several exceptionally wet years in the early 1970s. In 1960, flows fell below the 65 cfs target for about 30 days. By 1990, flows were lower than 65 cfs for more than 60 days. Average annual flows appear to have declined from 185 cfs in 1960 to 148 cfs in 1990 (-37 cfs) (Covert *et al.* 1995). No analysis was performed to determine the cause of the apparent decline in average annual flow. For all practical purposes the Tucannon River is closed to further appropriations (Ducharme 2002, personal communication).

Biological Processes

Reduced levels of marine-derived nutrients contributed by anadromous fish (i.e. eggs, juveniles, and decomposing carcasses) likely limit productivity. For example, as recently as the late 1950s, about 5,000 spring chinook returned to the Tucannon River System. At an average weight of 10-pounds per fish, a total of 50,000-pounds of carcasses would have been present following spawning. In 1995, a record low return of 54 spring chinook would have provided only 540-pounds of carcasses. This example doesn't consider the historic nutrient contribution provided by coho that were once abundant (Mendel 2002a, personal communication), but have been extinct since 1929 (Parkhurst 1950).

Tucannon River (U.S. Highway 12 to mouth)

Habitat Ratings

Fish Passage

A fish ladder was installed at Starbuck Dam (RM 5.5) in 1992 (Northwest Power Planning Council 2001e). The ladder is primarily used by fall chinook and is designed to prevent northern pikeminnow and suckers from migrating from the Snake River reservoirs into the majority of the Tucannon River. Steelhead and spring chinook typically jump the dam. A bedrock falls about ¼ to ½ mile downstream from Highway 12 and a boulder dam that supplies water to a diversion are likely partial barriers (Mendel 2002a, personal communication).

Screens and Diversions

State-of-the-art screens were installed on many diversions along the Tucannon from 1990 to 1992 (Johnson 1995). However, it is not known if these screens meet current state and federal screening regulations. A diversion at the boulder dam described above and several small pumps are known to be in use. No information on the total number of diversions currently in use was available (TAG 2001, personal communication).

Riparian Condition

Acreage of riparian woodlands decreased an average of 33% to 50% on the Tucannon by 1981. Much of the riparian conversion below Marengo predated the 1964-65 floods (Esmaili and

Associates 1982). Immature alders dominated this reach of the Tucannon River when evaluated in 1994. The small trees provided an average canopy cover of 46% (Columbia Conservation District 1997). Significant acreages along this reach have been enrolled in the CREP. If the plantings are successful, riparian conditions should improve (TAG 2002, personal communication).

Streambank Condition

The banks of the Tucannon River are composed primarily of coarse gravel and cobble bound by a silt-clay matrix. Little sand or fine gravel are present. A rough estimate of channel changes on the Tucannon from Pataha Creek downstream is: 1937-54 (40%), 1954-64 (20%), and 1964-78 (40%). Study of aerial photos from 1937 and 1978 revealed that channel braiding was prevalent throughout the length of the river by 1978 and composed 50% of channel length. Braiding was most severe in places that were tightly curved meanders in 1937. Removal of riparian forests caused by flooding, channel modifications, and conversion to other land uses contributed to and continues to maintain eroding streambanks (Esmaili and Associates 1982, Columbia Conservation District 1997). No information was available following the 1996-97 floods.

Floodplain Connectivity

A riprapped railroad bed constructed in the 1880s runs from Pataha Creek to Smith Hollow. The dike keeps the river from cutting into the north valley wall, but does not constrain other processes. Following the 1964-65 floods the SCS and the USACE installed up to 40,000 feet of riprapped levees along the Tucannon, while the state, county, and private parties installed between 20,000 and 40,000 additional feet of levees. Much of the construction took place following the 1969 storms. Each road or rail crossing of the Tucannon typically consists of a bridge and causeway that often extends the full width of the valley floor. These structures alter the channel for several hundred feet upstream and downstream from the crossing and likely contribute to maintenance of the braided channel form (Esmaili and Associates 1982).

Width/Depth Ratio

No information was available.

Substrate Embeddedness

This reach of the Tucannon River is subject to high inputs of fine sediments eroded from cropland and transported through the drainage network, particularly Pataha Creek. Studies conducted during 1979-80 described highly embedded substrate that would make redd construction difficult and likely reduce survival of incubating juvenile salmonids (Kelley and Associates 1982). The fine sediment is rich in organic matter (finely divided grasses and crop residue) that may deplete dissolved oxygen levels within the substrate (Esmaili and Associates 1982). The bed of the Tucannon is composed primarily of coarse gravel and cobbles held together by a silt-clay matrix. Little sand or fine gravel are present. The bed of the Tucannon River becomes mobilized at flows of 250 to 300 cfs (Esmaili and Associates 1982). Bankfull flow at the USGS gage near Starbuck is 1,000 cfs (Columbia Conservation District 1997). Following the 1996-97 floods (5,580 cfs) the Tucannon substrate was definitely not embedded with fine sediment (Southerland 2001, personal communication). In the absence of a flooding such as the 1996-97 events, continued fine sediment contributions from Pataha Creek are expected to cause highly embedded substrate conditions (TAG 2002, personal communication).

Large Woody Debris

No information was available.

Pool Frequency

In 1994, approximately 9% of this reach was composed of pools. Large pools (≥ 3' deep with ≥ 25 yd^2 surface area) occurred at an average frequency of 15 pools per mile, while 28 small pools (≥ 0.5' deep with ≥ 1 ft^2 surface area) per mile were found (Columbia Conservation District 1997).

Pool Quality

Long-term residents of the Tucannon Valley reported that pools were common years ago. In fact, many were deep enough to dive into or swim a horse. Most of the pools were formed by logjams and boulders that were washed out in the 1964-65 floods (Kelley and Associates 1982). Large pools with LWD increased in frequency following the 1996-97 floods. An average of 28% of large pools and 23% of small pools on this reach of the Tucannon were associated with large woody debris (Columbia Conservation District 1997).

Off-Channel Habitat

Off-channel habitat is relatively common. Backwaters, side channels, and swampy areas are all present (Mendel 2002a, personal communication).

Water Quality/Temperature

Total suspended solids (TSS) concentrations exceeded 200,000 mg/L during the 1964-65 floods (Esmaili and Associates 1982). Dissolved oxygen levels in artificially constructed redds were low enough that survival of juvenile salmonids would have been severely impaired. Highly embedded substrate prevented water circulation through the redds. August water temperatures on this reach were high enough to stress juvenile salmonids. Few young of the year steelhead, no yearling steelhead, and no salmon were captured (Kelley and Associates 1982). In 1984, sheet and rill erosion of cropland carried 129,000 tons of fine sediment per year to the Tucannon River and Pataha Creek (USDA Soil Conservation Service *et al.* 1984). Many producers are converting to no-till/direct seed farming methods to reduce soil erosion and improve water infiltration (TAG 2001, personal communication). Maximum water temperatures during July and August 1999 and 2000 were nearly always at or above 75 °F and reached 80 °F on several occasions at Powers Bridge (RM 2.3) (Snake River Lab 2001). Mean water temperatures at the Smolt Trap (RM 1.7) frequently exceeded 70 °F during summer 2001. Maximum temperatures often exceeded 75 °F and approached or reached 80 °F for five days (Bumgarner 2002).

Water Quantity/Dewatering

The maximum flow recorded on the Tucannon River was 7,980 cfs on December 22, 1964 (Esmaili and Associates 1982). The 1996-97 flood produced a flow of 5,580 cfs (Columbia Conservation District 1997). The lowest flow recorded on the Tucannon was 15 cfs on July 11-12, 1930 (Johnson 1995). The majority of landowners on the lower 30 miles of the Tucannon obtain water for summer irrigation. Historically low wing dams and permanent low-head dams were used to divert surface water to sprinkler systems or irrigation ditches. The diversions did not appear to diminish streamflow in a biologically significant manner (Kelley and Associates 1982). By 1980, only four gravity diversions remained in use; the remainder had been converted to pump diversions (Johnson 1995). From 1960 to 1990, the seven-day low flow on the Tucannon fell below the 65 cfs minimum flow at the Starbuck gage nearly every year with the exception of several years in the early 1970s. In 1960, flows fell below the 65 cfs target for about 30 days. By 1990 flows were lower than 65 cfs for more than 60 days (Covert *et al.* 1995).

Change in Flow Regime

As of 1995, Washington Department of Ecology had issued 67 surface water rights (60 cfs) and 54 ground water rights (24 cfs) in the Tucannon Basin. Claims that predate state issued water rights total 133 cfs of surface water and 11 cfs of groundwater. Tucannon water claims have not been adjudicated, so WDOE does not know how many of the claims are valid. Tucannon flows were below the 1993 IFIM recommendations (minimum of 65 cfs at Starbuck Dam) more than 50% of the time during late July, August, and early September. Ground water provides nearly all summer base flow on the Tucannon. Mean annual flow of the Tucannon decreased 37 cfs from 1959 to 1990 (Covert *et al.* 1995). No analysis was performed to determine the cause of the apparent decline in average annual flow. A large number of claims and rights on the Tucannon are "paper rights" and are not being used. For all practical purposes the Tucannon River is closed to further appropriations (Ducharme 2002, personal communication).

Biological Processes

Smallmouth bass and channel catfish are present in the lower mile of the Tucannon. Grass pickerel are presumed to have migrated from the Palouse River to the lower Tucannon (Northwest Power Planning Council 2001e). Reduced levels of marine-derived nutrients contributed by anadromous fish (i.e. eggs, juveniles, and decomposing carcasses) likely limit productivity. For example, as recently as the late 1950s, about 5,000 spring chinook returned to the Tucannon River System. At an average weight of 10-pounds per fish, a total of 50,000-pounds of carcasses would have been present following spawning. In 1995, a record low return of 54 spring chinook would have provided only 540-pounds of carcasses. This example doesn't consider the historic nutrient contribution provided by coho that were once abundant (Mendel 2002a, personal communication), but have been extinct since 1929 (Parkhurst 1950).

Pataha Creek (Headwaters to Columbia Center)

Habitat Ratings

Fish Passage

Several large logjams form impassable barriers on the reach from the USFS boundary downstream to Columbia Center (Pomeroy Conservation District 1998). The logjams have apparently washed away since they were not observed in recent WDFW surveys (Mendel 2002a, personal communication). Several private culverts under driveways crossing the creek appeared to be undersized when inventoried in 1994 (Pomeroy Conservation District 1998). Culverts under Forest Roads 4016 and 040 allow fish passage (Forest Service 1992i, unpublished work). Anadromy above Columbia Center is unlikely (Mendel 2001, personal communication, Groat 2001, personal communication).

Screens and Diversions

The USFS maintains an unscreened diversion at the USFS boundary to supply Pataha Pond. Numerous off-channel watering diversions are presumed to be in use in the private residences along Pataha Creek Road (Groat 2001, personal communication).

Riparian Condition

Mature stands of fir dominated riparian vegetation from the USFS boundary upstream 6.8 miles when surveyed in 1992. Canopy cover was estimated at 43.5%. Grazing and logging were evident (Forest Service 1992i, unpublished work). From the USFS boundary downstream to Columbia Center about 50% of the reach had adequate riparian vegetation. Large trees were the dominant vegetation from Columbia Center upstream. Canopy cover ranged from 27% to 85% (Pomeroy Conservation District 1998).

Streambank Condition

Bank cover on the USFS portion of Pataha Creek ranged from 50 to 75% in 1992 (Forest Service 1992i, unpublished work). The majority of banks from the USFS boundary downstream to Columbia Center have been degraded by cattle grazing and numerous private road crossings (Pomeroy Conservation District 1998, Mendel 2001, personal communication).

Floodplain Connectivity

Pataha Creek Road parallels the stream from Columbia Center to about one mile above the USFS boundary.

Width/Depth Ratio

Data from summer 1986 WDFW stream surveys were used to calculate a mean width/depth ratio of 28.6 (Schuck *et al.* 1988). The width/depth ratio on the portion of stream on USFS lands varied from 5 to 6.2 in 1992 (Forest Service 1998, unpublished work).

Substrate Embeddedness

Embeddedness on USFS lands was >35% during 1992 surveys (Forest Service 1992i, unpublished work). Substrate at the USFS boundary was primarily gravel and rubble cemented with fine sediment. Embeddedness was 50% with a layer of fine sediment covering all rock surfaces (Catts and Rabe 2000).

Large Woody Debris

Large wood was plentiful on Pataha Creek in 1992 with 221 pieces per mile inventoried on 6.8 miles of stream on USFS lands (Forest Service 1992i, unpublished work). Private lands downstream host moderate levels of LWD, primarily stored in small debris jams (Mendel 2001, personal communication).

Pool Frequency

Pools were relatively common on Pataha Creek in 1992 with 28.5 pools/mile comprising 14% of stream surface area (Forest Service 1992i, unpublished work). The pool/riffle/glide ratio at the USFS boundary was 11%: 81%: 8% respectively (Catts and Rabe 2000).

Pool Quality

Residual pool depth on USFS lands was 1.0' in 1992 (Forest Service 1992i, unpublished work). The majority of pools from the USFS boundary downstream to Columbia Center were shallow when assessed in 1994, but small brook trout and rainbow trout were present (Pomeroy Conservation District 1998).

Off-Channel Habitat

Side channels comprised only 0.2% of stream surface area on the USFS portion of Pataha Creek when surveyed in 1992. The average gradient was 2% (Forest Service 1992i, unpublished work). No off-channel habitat was present on private lands downstream from the USFS boundary (Mendel 2001, personal communication).

Water Quality/Temperature

Total suspended solids (TSS) levels at the USFS boundary exceeded 80 mg/L twice from September 1998 to April 2001, whiles levels at Columbia Center exceeded that level eight times during the same time period. The highest TSS measurement was 584 mg/L on May 31, 2000. Water temperature (grab sample) never exceeded 65 °F at the USFS boundary during the above monitoring period, but it reached 70 °F in July 1999 and 65 °F in July 2000 (Washington State University Center for Environmental Education 2001b, unpublished work). Daily minimum, maximum, and average water temperatures were not available for Pataha Creek.

Water Quantity/Dewatering

Flow 200 feet below the culvert at Iron Springs Road was measured at 1.2 cfs in early September 1998. Flow 100 feet above the culvert at Columbia Center was measured at 1.1 cfs at the same time (Mendel 1999). The highest flows measured at the USFS boundary were 38.9 cfs in May 1999 and 28.6 cfs in May 2000. Low flows at the same location were 0.5 cfs in mid-December 1999 and 0.7 cfs in mid-August and mid-November 2000 (Washington State University Center for Environmental Education 2001b, unpublished work).

Change in Flow Regime

The natural flow regime is presumed to be present on this reach (TAG 2001, personal communication).

Biological Processes

A naturally reproducing population of brook trout is present on this reach. The population was introduced by Washington Department of Game, but stocking was discontinued by 1980 at the latest. Adult fish have been observed spawning (Pomeroy Conservation District 1998, Mendel 2001, personal communication). Reduced levels of marine-derived nutrients contributed by anadromous fish (i.e. eggs, juveniles, and decomposing carcasses) likely limit productivity (Mendel 2002a, personal communication).

Pataha Creek (Columbia Center to Benjamin Gulch Road Bridge in Pomeroy)

Habitat Ratings

Fish Passage

Refuse dams just upstream from Columbia Street in Pomeroy may impede passage. Abandoned concrete slabs covered with mud and reed canary grass had formed a dam downstream from the well site for the town of Pataha. This dam appeared to be impassable to all fish except at high flows. A bedrock falls four to six feet high at the Davis Farm was impassable to all fish except during flood flows when the stream bypassed the falls through an adjacent field (Pomeroy Conservation District 1998). The stream eventually cut a new channel around the falls, eliminating the passage problem. A bedrock shelf near the Clay Bar Ranch is likely a barrier at low flows, but is likely passable by steelhead during high spring flows (Bartels 2002, personal communication).

Screens and Diversions

No information was available.

Riparian Condition

This reach is heavily impacted by cattle grazing. Almost no riparian vegetation was present from the Davis Farm to one mile below Columbia Center during 1994 surveys. Riparian vegetation was present from Columbia Center about one mile downstream. Stand composition ranged from grass/forb to all age classes of trees. Canopy cover ranged from 5% to 37%. (Pomeroy Conservation District 1998).

Streambank Condition

Large portions of streambanks are eroding. The majority of the reach is characterized by an incised channel, particularly near Pomeroy (Mendel 2001, personal communication).

Floodplain Connectivity

The stream has access to the floodplain, mainly in the upper portion of the reach where the channel is not incised (Mendel 2001, personal communication).

Width/Depth Ratio

No information was available.

Substrate Embeddedness

Gravel and rubble were the dominant substrate at Columbia Center. Embeddedness was 55% with fine sediment covering 100% of all rock surfaces (Catts and Rabe 2000). Embeddedness tends to increase as one moves downstream. In some cases gravels and cobbles are completely obscured by mud (Mendel 2002a, personal communication).

Large Woody Debris

Woody debris is very limited, almost non existent on this reach (Mendel 2001, personal communication).

Pool Frequency

The channel at Columbia Center was comprised of 50% pools, 38% riffles, and 12% glides (Catts and Rabe 2000). This ratio was obtained from a limited sample size and may not accurately reflect average condition of the reach as a whole.

Pool Quality

No information was available.

Off-Channel Habitat

Channel incision makes off-channel habitat very rare (Mendel 2002a, personal communication).

Water Quality/Temperature

No information was available. Bihmaier Spring provides a cool water influence just upstream from Benjamin Gulch Road (Mendel 1999).

Water Quantity/Dewatering

No information was available.

Change in Flow Regime

No information was available.

Biological Processes

Brook trout were observed in this reach (to just downstream of Columbia Center) during 1994 and 1998 stream surveys (Pomeroy Conservation District 1998, Mendel 1999). Reduced levels of marine-derived nutrients contributed by anadromous fish (i.e. eggs, juveniles, and decomposing carcasses) likely limit productivity (Mendel 2002a, personal communication).

Pataha Creek (Benjamin Gulch Road Bridge in Pomeroy to mouth)

Habitat Ratings

Fish Passage

A high gradient culvert under US Highway 261 near Delaney (RM 1.1) may be a partial barrier at some flows (Mendel 1999). A concrete apron spans the channel under the US Highway 12 bridge at Dodge (RM 10.7). An 18" drop on the downstream end, and shallow sheeting flow over the apron are potential juvenile barriers. No barriers are known to be present from Dodge to Tatman Gulch (RM 19). A concrete slab poured over a pipe at 20th Street in Pomeroy is impassable to most fish (Pomeroy Conservation District 1998).

Screens and Diversions

Several diversions were present from the mouth to Dodge Junction (intersection of U.S. Highway 12 and State Route 127), some of which were not screened to protect juvenile salmonids (Pomeroy Conservation District 1998).

Riparian Condition

Extensive channel incision and the associated drop in ground water table, livestock grazing, land clearing, tillage, and herbicide use removed the majority of native woody trees and shrubs from banks along this reach. Woody riparian plants on this reach consisted primarily of shrubs growing on the floodplain forming in the bottom of the incised channel or the sides of the channel. Reed canarygrass was the dominant riparian vegetation. Canopy cover ranges from 5% to 15%. Current practices of tilling to the edge of the terrace, grazing, and herbicide application are contributing to maintenance of the degraded riparian conditions (Pomeroy Conservation District 1998).

Streambank Condition

This reach is extensively incised into tight silt/clay soils overlaying basalt. In many areas the stream has downcut to the basalt bedrock, a depth of 10 to 15 feet from Dodge upstream to Sweeney Gulch and 20 to 25 feet from Dodge downstream to the mouth (Esmaili and Associates 1982). Bank erosion caused by livestock access and high stream flows was evident throughout the reach from Dodge to the mouth. A large portion of banks in the city of Pomeroy were vertical walls reinforced with sack-crete, concrete, or rip-rap (Pomeroy Conservation District 1998).

Floodplain Connectivity

An extensive wetland complex was present near Dodge until the early 1900s when a local farmer channelized Pataha Creek to drain the wetlands. The channel modification coupled with conversion of thousands of acres of perennial grasslands to dryland wheat production led to rapid downcutting throughout the length of the stream channel. The historic floodplain became a terrace which no longer had a water table to support riparian vegetation (Pomeroy Conservation District 1998) (See Figure 24).

Figure 24. Farming to the edge of terrace on Pataha Creek about 1/4 mile downstream from Dodge. Note the stream is hidden in the incised channel marked by trees. Photographed 9/26/2001.

Width/Depth Ratio

No information was available, but the incised channel condition suggests that the stream is likely relatively narrow and deep (TAG 2001, personal communication).

Substrate Embeddedness

Mendel (1999) noted gravel and cobble substrate, boulders, and bedrock shelves throughout portions of this reach. Most rock surfaces were covered with a layer of silt. Gravel and cobble were generally embedded. Substrate at Zumwalt was dominated by rubble and cobble. Embeddedness at this site was 100% (Catts and Rabe 2000).

Large Woody Debris

Mendel (1999) did not describe any large woody debris on this reach. No quantitative information was available, but LWD is suspected to be uncommon because of the highly degraded riparian conditions and channel incision (TAG 2001, personal communication).

Pool Frequency

Few pools are present on the reach from Dodge downstream (Pomeroy Conservation District 1998). The channel at Zumwalt was comprised of 63% glides and 37% riffles. No pools were identified (Catts and Rabe 2000).

Pool Quality

Pools described in Mendel (1999) were generally small with a muddy bottom. Overhanging grass provided some vegetative cover. Pools are suspected to be small with little instream or vegetative cover because of degraded riparian conditions, channel incision, and suspected low LWD abundance (TAG 2001, personal communication).

Off-Channel Habitat

Little or no off-channel habitat is present because of channel incision (Mendel 2002a, personal communication).

Water Quality/Temperature

Total suspended solids (TSS) levels exceeded 80 mg/L seven times from September 1998 to April 2001. The highest value measured was 1,444 mg/L at Delaney (just above the mouth) on March 1, 1999. Water temperatures (grab sample) exceeded 70 °F in July and August 1999 and exceeded 65 °F in July and August 2000 (Washington State University Center for Environmental Education 2001b, unpublished work). Daily minimum, maximum, and average water temperature data were not available for Pataha Creek.

Water Quantity/Dewatering

The highest flows measured at Delaney were 35.1 cfs in April 1999 and 34.1 cfs in April 2000. Low flows at the same location were 2.2 cfs in late September 1999 and 0.2 cfs in mid-August 2000 (Washington State University Center for Environmental Education 2001b, unpublished work). Permits, claims, and certificates on file with WDOE identify a potential instantaneous withdrawal of 4.11 cfs of flow or 766.5 acre-feet per year of water from Pataha Creek (Neve 2001, personal communication).

Change in Flow Regime

No information was available.

Biological Processes

Reduced levels of marine-derived nutrients contributed by anadromous fish (i.e. eggs, juveniles, and decomposing carcasses) likely limit productivity (Mendel 2002a, personal communication).

TUCANNON SUBBASIN RECOMMENDATIONS

Protect the remaining high quality (but limited) Tucannon River salmonid spawning and rearing habitat (primarily from the lower end of the Wooten Wildlife Area upstream).

Restore "normative" channel processes (where feasible) on the Tucannon River by removing or setting back dikes, removing bank armoring, restoring a meandering single-thread stream channel, and replanting woody riparian vegetation on the floodplain. Restoration of channel pattern, dimension, and profile will allow the river to transport its water and sediment load efficiently (Rosgen 1996).

Reduce and/or eliminate further development on the Tucannon River floodplain. Where possible restore floodplain connectivity.

Inventory all surface water diversions on the Tucannon River and evaluate compliance with state and federal screening criteria. Screen all diversions to meet requirements.

Increase summer instream flows through surface water leases and/or purchases, or irrigation efficiency improvements, no-till/direct seed, and other means.

Restore connectivity between the main channel of the Tucannon River and historic side channel habitats through dike removal or setback and/or meander reconstruction.

Continue to reduce fine sediment inputs to the Tucannon River and Pataha Creek through implementation of no-till/direct seed farming methods and CRP.

Restore riparian forests along the Tucannon River, particularly from the Wooten Wildlife Area downstream. Continue to reduce recreational impacts to riparian areas on public lands in the Umatilla National Forest and the Wooten Wildlife Area.

Evaluate bridge crossings on the Tucannon River and attempt to redesign crossings to allow channel meandering. Investigate the feasibility of installing culverts under valley spanning causeways to allow passage of floodwaters.

Practice proper riparian vegetation management to ensure healthy vigorous plant growth of woody vegetation and natural regeneration. Best management practices (BMPs) could include, but are not limited to: limited riparian "flash grazing," pasture rotation, fencing livestock out of streams and riparian areas, and development of off-site watering facilities.

Reduce summer stream temperatures with restoration of riparian forest buffers.

Inventory habitat conditions as well as fish presence and relative abundance on the Tucannon River and tributary streams every five years to fill data gaps and monitor success of habitat restoration projects. Conduct continuous monitoring of water quality parameters such as water temperature and total suspended solids.

Enforce existing land use regulations including Critical Area Ordinances, Shoreline Management Act, and the Growth Management Act.

SNAKE SUBBASIN HABITAT LIMITING FACTORS

Lower Snake Subbasin Description (WRIA 33)

The Lower Snake Watershed (WRIA 33) begins at the confluence of the Palouse and Snake Rivers and continues downstream to the mouth of the Snake at the Columbia River. The basin covers approximately 722 square miles. The Lower Snake Watershed encompasses portions of Columbia, Franklin, and Walla Walla Counties (See Map 1). This portion of the Snake River is primarily a migration corridor for anadromous salmonids. No tributaries are known to support salmonid populations. Limited fall chinook spawning occurs in the tailraces of Lower Monumental and Ice Harbor Dams (Dauble 2000). Fulton (1968, cited in Dauble 2000) reported sizable fall chinook spawning grounds near the mouth of the Palouse River. With the exception of passage issues through the lower Snake River dams and reservoirs, habitat issues on the mainstem Snake River will not be evaluated in this report.

Middle Snake Subbasin Description (WRIA 35)

The Middle Snake Subbasin encompasses the entire Snake River mainstem from the Oregon-Washington border downstream to the Palouse River (approximately 676 square miles) (See Map 16). Dryland agriculture is the dominant land use on ridge tops while livestock grazing dominates on the steep canyon slopes. About 1,115 acres of cropland in Asotin County are currently enrolled in CRP (Johnson 2001, personal communication). The Snake River is used as a major transportation corridor to export grain and wood products and import fuel and other materials by barge. The City of Lewiston is the furthest inland seaport (468 miles from the Pacific Ocean) on the U.S. west coast (Dietrich 1997). Clarkston (population 7,737) and Clarkston Heights (population 6,117) are the largest population centers in the subbasin (Census Bureau 2001b). Intermittent and/or ephemeral streams are present throughout the watershed. Under typical conditions these streams do not convey much water, but during thunderstorms or rain-on–snow events they are capable of carrying immense debris torrents into the Snake River. The sediment moving capacity of these small streams is easily seen in the extensive alluvial fans deposited at their mouths.

Spring chinook and summer steelhead use the Snake River to migrate to and from the ocean and between tributary streams, while fall chinook and bull trout use the Snake for migration and rearing. Sockeye migrate through this corridor to and from spawning grounds in Idaho's Salmon River Basin. Some fall chinook spawning occurs from the city of Asotin upstream to Hells Canyon Dam. Summer steelhead/resident rainbow trout are known to be present in Wawawai Creek, Almota and Little Almota Creeks, Penawawa Creek, and Alkali Flat Creek; and presumed to be present in Steptoe Creek, an unnamed tributary near Knoxway Canyon in Garfield County, and Mud Flat Creek (tributary of Alkali Flat Creek) (See Appendix B). Habitat conditions on the assessed Snake River tributary streams are generally in poor to fair condition (See Table 10).

Snake River Mainstem Habitat Limiting Factors (WRIAs 33 & 35)

This report focuses on habitat conditions on tributaries of the Snake River and will not evaluate conditions on the Snake River mainstem. The four lower Snake River dams (and McNary Dam downstream on the Columbia) have inundated mainstem salmonid habitat from the mouth of the Snake River upstream to the City of Asotin, Washington (RM 146). The pooled reaches represent about 83% of the Snake River from the mouth upstream to the Washington-Oregon border (RM 176). Passage of salmonids through the four lower Snake River dams and their associated reservoirs is the primary issue on the Washington portion of the mainstem Snake River. Adult fish passage facilities were originally incorporated into each dam when constructed. Juvenile passage was not well understood until about 1997. Juvenile salmonid bypass systems and a transportation system of barges and trucks are currently operated at each dam. Juveniles have three routes to pass dams: through turbines, juvenile bypass systems, or over spillways (Army Corps of Engineers 1999).

From 1966-1967 (when only four dams were in place on the lower Columbia), estimated survival of juvenile salmonids through the entire hydro system (Snake and Columbia Rivers) was 32 to 56%. During the 1970s (when the four lower Snake River Dams were built), survival estimates for spring/summer chinook juveniles were typically 10 to 30%, but less than 3% in the drought years of 1973 and 1977. After structural and operational improvements at the lower Snake River dams from 1993 to 1999, survival estimates for juvenile spring/summer chinook and steelhead ranged from 31 to 59% (Williams *et al.* 2001).

Muir *et al.* (2001) investigated survival of juvenile chinook and steelhead passing the lower Snake River Dams. Survival was highest through spill bays without flow deflectors (98.4 to 100%). Spill bays with flow deflectors had the second best survival rate (92.7 to 100%). Juveniles spilled over the dams may suffer from gas bubble trauma similar to the bends suffered by scuba divers. This problem has been reduced by the installation of flow deflectors (often called "flip lips") that reduce air entrainment (Muir *et al.* 2001). Juveniles can be disoriented in the fall over spillways thus becoming more vulnerable to predation by fish and birds (Army Corps of Engineers 1999). Survival through bypass systems and turbines was (95.3 to 99.4%) and (86.5 to 93.4%) respectively. In the absence of spill, 69 to 78% of yearling chinook and 82 to 92% of steelhead smolts that entered powerhouse turbine intakes were guided into fish bypass systems (Muir *et al.* 2001). More than 50% of juvenile salmonids (up to 15 million) migrating down the lower Snake River are captured for transport. Juvenile salmonids are guided into fish bypass systems by submerged screens and behavioral guidance systems. The fish are either bypassed to the river below the dam or loaded onto barges or trucks and transported downstream below Bonneville Dam (RM 150) on the Columbia River (Army Corps of Engineers 1999).

Survival through the transportation system is 98 to 99%. Survival through each dam and reservoir on the lower Snake River is about 95%. The cumulative survival through all four dams and reservoirs is over 80% (i.e. in-river migration). Cumulative survival of juvenile salmonids through the lower Snake River dams and the four Columbia River dams downstream ranges from 88 to 94%. Survival through each individual project is 97 to 98%. Indirect or delayed mortality of juveniles downstream from Bonneville Dam is not well understood (Army Corps of Engineers 1999).

The reservoirs impounded by each dam have slowed river currents thereby increasing outmigration time of juvenile salmonids (See Figure 25 and Figure 26). The reservoirs have also improved habitat for predatory species including northern pikeminnow, smallmouth bass, and channel catfish. Increased travel time and higher predator populations combine to reduce survival of juvenile salmonids in the lower Snake River (Northwest Power Planning Council 2001c).

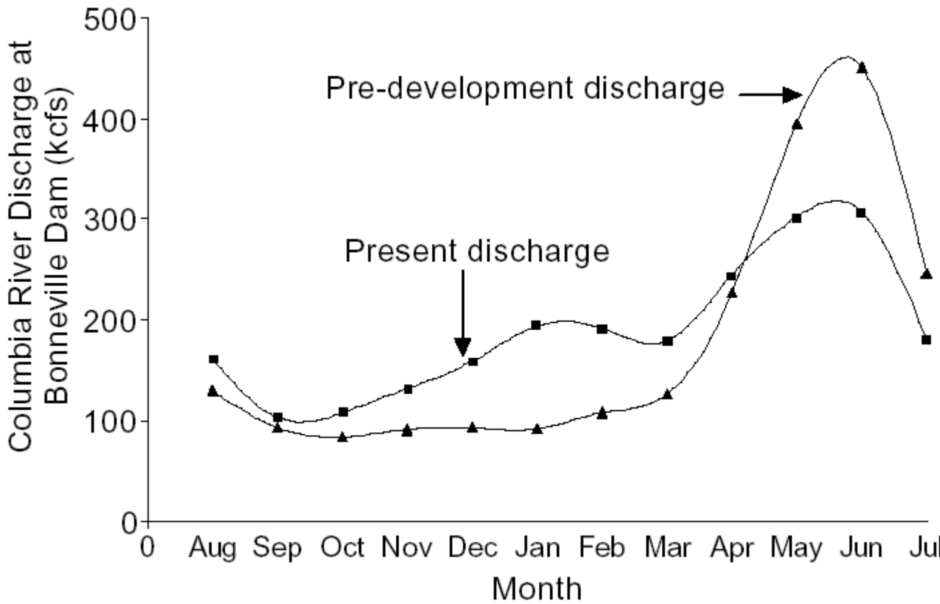

Figure 25. Average monthly flows at Bonneville Dam under present operating conditions of the Columbia River hydropower system compared to flows that would have occurred if no storage reservoirs were in place. Source: (Northwest Fisheries Science Center 2000, Figure 1).

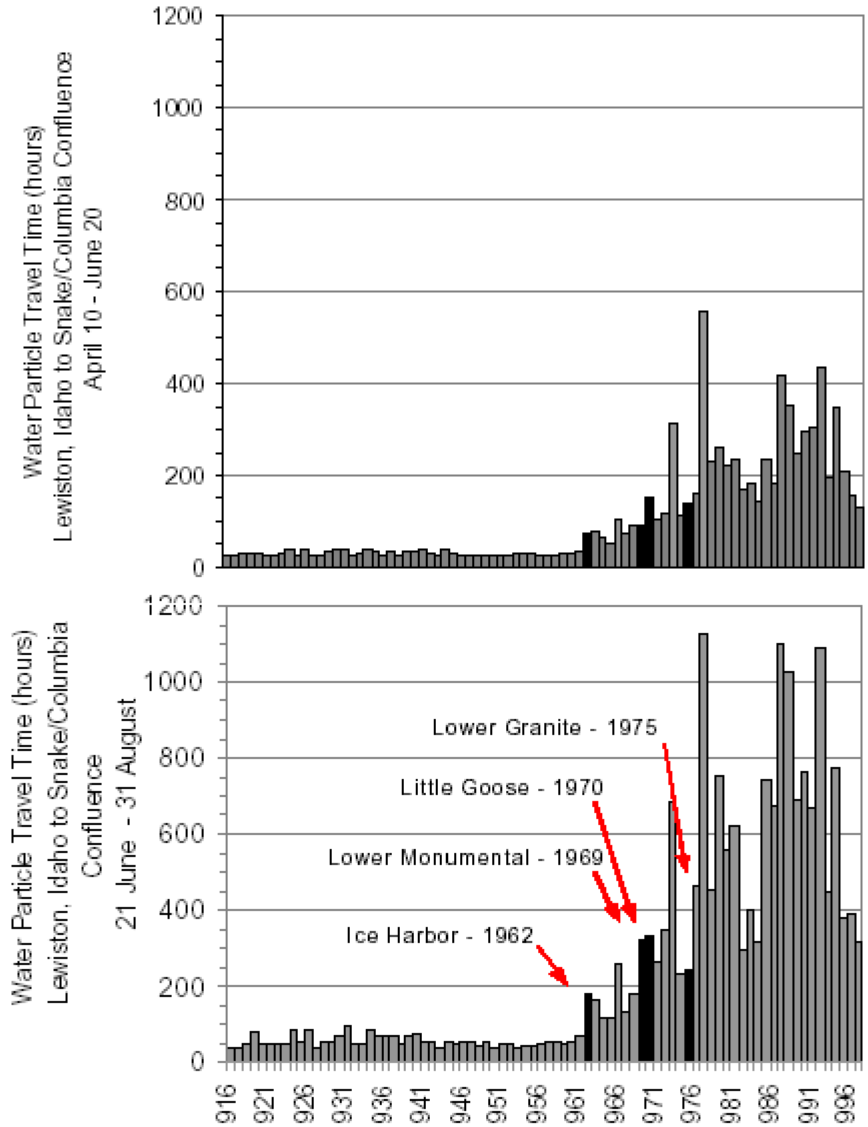

Figure 26. Estimated seasonal average water particle travel times from Lewiston, Idaho to the Snake and Columbia River confluence (after Dreher 1998). Source: (Northwest Fisheries Science Center 2000, Figure 2).

Snake River Fish Bearing Tributary Streams Including: Steptoe, Wawawai, Almota, Little Almota, Penawawa, and Alkali Flat Creeks (WRIA 35)

Note: Alkali Flat and Penawawa Creeks have not been evaluated, but work is planned in 2002. Conditions are likely similar to those described on the other tributaries. Steptoe Creek was hit by a major flash flood during late summer 2001. The flood scoured out portions of the channel and deposited large amounts of gravel in some areas.

Habitat Ratings

Fish Passage

Six barriers were identified on Steptoe Creek from the mouth upstream to RM 1.1. No descriptions were available. Three barriers, one reach of steep gradient and two falls 2.5' high, were found on Steptoe Creek from RM 1.1 to RM 2.1 (Mendel 2001, unpublished work). A flash flood in summer 2001 created at least one perched culvert on Steptoe Creek. Several other culverts may hinder fish passage. The flood created a delta just upstream from the mouth which may limit passage during low flows (Mendel 2002a, personal communication). A logjam of driftwood at the mouth of Wawawai Creek is a barrier (Mendel 2001, unpublished work). A culvert under Wawawai Grade Road (RM 0.1) on Wawawai Creek is a barrier. Adult steelhead have been observed blocked below the culvert on several occasions by WDFW personnel (Mendel 2001, personal communication). Little Almota Creek had 13 barriers, including three waterfalls, from the mouth to RM 5.2 (Mendel 2001, unpublished work). No barriers are known to exist on Almota Creek (Mendel 2002a, personal communication).

Screens and Diversions

No diversions were in use on Steptoe Creek from the mouth to RM 2.1. No diversions were in use on Wawawai Creek from the mouth to RM 0.1. No diversions were in use on Almota Creek from RM 1.0 downstream or RM 2.0 to RM 4.7. No diversions were present from the mouth to RM 5.2 on Little Almota Creek (Mendel 2001, unpublished work).

Riparian Condition

Forbs, some trees, and grazed pasture were the primary riparian vegetation along Steptoe Creek from the mouth to RM 1.1. Trees averaged 15' in height with an average maximum of 25'. The average buffer width was 6.7', providing only 4% shading. There was generally no woody riparian buffer along Steptoe Creek from RM 1.1 to RM 2.1. The narrow, rocky canyon and livestock grazing limited riparian vegetation. Grasses, sedges, rushes, and grazed pasture were the primary vegetation in the riparian zone, but some small deciduous trees averaging 6' tall with a maximum height of 20' were present. The limited buffer provided an average of 30% shading. The riparian buffer along Wawawai Creek from RM 0.1 downstream was composed of shrubs and small trees 7' to 30' tall. The buffer was 30' to 40' wide. Forbs and deciduous trees were the primary riparian vegetation on Almota Creek from the mouth to RM 1.0. Average height was 15' with an average maximum height of 31'. The buffer averaged 47' wide. Grasses, sedges, rushes, and deciduous trees were found on Almota Creek from RM 2.0 to RM 4.7. The average riparian height was 19' with an average maximum of 36'. The buffer averaged 38' wide. Shading on both reaches of Almota Creek averaged 54% (Mendel 2001, unpublished work). No measurements were taken upstream from RM 4.7. The riparian vegetation upstream has likely been degraded by intensive agriculture and roads (Mendel 2002a, personal communication). The riparian buffer from the mouth to RM 1.4 on Little Almota Creek was composed of forbs, shrubs, and deciduous trees. The average height was 10' with an average maximum height of 30'. The average buffer width was only 3.3', providing an average of 30% shading. Grasses and shrubs dominated the riparian understory along Little Almota Creek from RM 1.4 to RM 5.2, while deciduous and coniferous trees dominated the overstory. The mean riparian height was 27.5' with an average maximum height of 87'. The buffer averaged 128' in width. Shading averaged 63% (Mendel 2001, unpublished work).

Streambank Condition

Livestock grazing had caused moderate damage to banks on Steptoe Creek from the mouth to RM 1.1. Banks were somewhat stable with an average of 27% of banks eroding. Banks were moderately to severely damaged by livestock grazing from RM 1.1 to RM 2.1 on Steptoe Creek. An average of 32.5% of banks were eroding (Mendel 2001, unpublished work). The flash flood during summer 2001 caused substantial erosion (Mendel 2002a, personal communication). Banks from RM 0.1 downstream on Wawawai Creek were generally stable with only 5 to 10% eroding banks and little or no damage from livestock grazing. Banks along Almota Creek showed moderate, but increasing damage as one moved downstream. An average of 48% of banks were eroding from RM 1.0 downstream, while an average of 35% of banks were eroding from RM 2.0 to RM 4.7. Banks showed moderate to severe damage from the mouth to RM 1.4 on Little Almota Creek. An average of 86% of banks were actively eroding. Banks were severely degraded along Little Almota Creek from RM 1.4 to RM 5.2. Nearly 100% of banks were actively eroding (Mendel 2001, unpublished work).

Floodplain Connectivity

Steptoe Creek did not have access to a floodplain from the mouth to RM 1.1 and little floodplain connectivity was present upstream to RM 2.1. A road and limited dikes reduce floodplain function. Wawawai Creek had access to a floodplain from RM 0.1 downstream. From RM 0.1 upstream floodplain access is limited by a road. Portions of Almota Creek from RM 1.0 downstream did not have access to a floodplain. A floodplain was usually present from RM 2.0 to RM 4.7 on Almota Creek. Some portions of Little Almota Creek from the mouth to RM 1.4 had a functional floodplain. Little floodplain was present along Little Almota Creek from RM 1.4 to RM 5.2 (Mendel 2001, unpublished work, Mendel 2002a, personal communication).

Width/Depth Ratio

Steptoe Creek had a width/depth ratio of 9 from the mouth to RM 1.1 and 13 from RM 1.1 to RM 2.1 (both ratios calculated from data collected prior to the flash flood of summer 2001). Wawawai Creek had a width/depth ratio of 13 from RM 0.1 to the mouth. Almota Creek had a width/depth ratio of 10 from RM 1.0 downstream. The channel was wider upstream with a width/depth ratio of 17 from RM 2.0 to RM 4.7. Little Almota Creek had a width/depth ratio of 10 from the mouth to RM 1.4 and a ratio of 12 between RM 1.4 and RM 5.2 (Mendel 2001, unpublished work).

Substrate Embeddedness

As of 1984, sheet and rill erosion of cropland carried 264,000 tons of fine sediment per year to the Snake River and independent tributary streams. Sheet and rill erosion of cropland in the Alkali Flat Creek Watershed carried 79,000 tons of fine sediment per year to Alkali Flat Creek during the same time period (USDA Soil Conservation Service *et al.* 1984). Cobble was the primary substrate in Steptoe Creek from the mouth to RM 1.1. Gravel and cobble were the dominant substrates upstream to RM 2.1. Embeddedness was generally 25 to 50% on both reaches of Steptoe Creek. Gravel and cobble with 25 to 50% embeddedness were the dominant substrate on Wawawai Creek from RM 0.1 downstream. Gravel and cobble were the dominant substrates on Almota Creek from RM 1.0 downstream. Embeddedness was generally 25 to 50% from RM 1.0 downstream and >25% between RM 2.0 and RM 4.7. Cobble and gravel were the primary substrate from the mouth to RM 1.4 on Little Almota Creek. Embeddedness was generally 25 to 50%. Boulders and mud were the primary substrate in Little Almota Creek from RM 1.4 to RM 5.2. Embeddedness was generally >50% on boulders and cobbles (Mendel 2001, unpublished work).

Large Woody Debris

Large woody debris was nearly non-existent on Steptoe Creek from the mouth to RM 2.1. Little woody debris was present in Wawawai Creek from RM 0.1 downstream. No LWD was present on Almota Creek from RM 1.0 downstream, but small amounts were found between RM 2.0 and RM 4.7. Woody debris was rare in Little Almota Creek from the mouth to RM 5.2 (Mendel 2001, unpublished work).

Pool Frequency

Steptoe Creek had 11 pools per mile from the mouth to RM 1.1 and 14 pools per mile from RM 1.1 to RM 2.1. Wawawai Creek had 30 pools per mile from RM 0.1 downstream, but part of this is backwater from the Snake River. Pools occurred at a frequency of 8 pools per mile on the lower mile of Almota Creek and 12 pools per mile from RM 2.0 to RM 4.7. Little Almota Creek had 3.6 pools per mile from the mouth to RM 1.4 and 5.5 pools per mile from RM 1.4 to RM 5.2 (Mendel 2001, unpublished work).

Pool Quality

Riffles and runs dominated all reaches of these streams. Pools were generally small with little or marginal cover. Turbulence was the dominant instream cover throughout the inventoried reaches (Mendel 2001, unpublished work).

Off-Channel Habitat

No side channels were present on Steptoe Creek from the mouth to RM 2.1. Some off-channel habitat was present on Wawawai Creek from RM 0.1 downstream. No off-channel habitat was present on the lower mile of Almota Creek, but several side channels were found from RM 2.0 to RM 4.7. No off-channel habitat was found on Little Almota Creek from the mouth to RM 5.2 (Mendel 2001, unpublished work).

Water Quality/Temperature

Mean daily water temperatures at RM 1.0 on Steptoe Creek frequently exceeded 65 °F in July and August 2001. Daily maximums frequently exceeded 70 °F and occasionally approached 80 °F during the same time period. Average water temperatures at RM 0.1 on Wawawai Creek frequently exceeded 60 °F from June through August 2001. However, daily maximums never reached 70 °F. Average water temperatures at RM 0.1 on Almota Creek frequently exceeded 65 °F and approached 70 °F during July and August 2001. Daily maximums often exceeded 70 °F from July through mid-September. Mean water temperatures at RM 5.1 on Little Almota Creek were frequently >60 °F with daily maximums near 70 °F from July to mid-August 2001. Temperatures were considerably warmer downstream at RM 0.1 with averages from 65 °F to 70 °F and daily maximums frequently 75 °F to 80 °F from July to mid-September 2001 (Mendel 2001, unpublished work).

Water Quantity/Dewatering

Flow at RM 1.0 on Steptoe Creek was 1.22 cfs on April 17, 2001; 0.16 cfs on July 9, 2001, and 0.65 cfs on October 18, 2001. Flow at RM 0.1 on Wawawai Creek was 0.43 cfs on October 18, 2001. Flow at RM 1.0 on Almota Creek was 0.92 cfs on September 18, 2001. Downstream at RM 0.1 flow was 3.99 cfs on April 24, 2001; 0.86 cfs on July 9, 2001; 0.85 cfs on September 18, 2001, and 1.65 cfs on October 18, 2001. Flow at RM 0.1 on Little Almota Creek was 1.07 cfs on April 24, 2001; 0.53 cfs on July 9, 2001; 0.64 cfs on September 18, 2001, and 0.66 cfs on October 18, 2001 (Mendel 2001, unpublished work).

Change in Flow Regime

Conversion of native prairie vegetation to largely agricultural production is suspected to have altered the flow regime, but there is no way to quantify the change if one exists (TAG 2001, personal communication).

Biological Processes

Reduced levels of marine-derived nutrients contributed by anadromous fish (i.e. eggs, juveniles, and decomposing carcasses) likely limit productivity (Mendel 2002a, personal communication).

SNAKE SUBBASIN RECOMMENDATIONS

Remove man made barriers on Steptoe Creek, Wawawai Creek. Little Almota Creek has so many barriers that there is little use attempting to provide passage. Evaluate culverts on Steptoe Creek to ensure that they are sized properly to pass water and sediment efficiently.

Restore riparian vegetation along salmonid-bearing tributary streams. Practice proper riparian vegetation management to ensure healthy vigorous plant growth of woody vegetation and natural regeneration. Best management practices (BMPs) could include, but are not limited to: limited riparian "flash grazing," pasture rotation, fencing livestock out of streams and riparian areas, and development of off-site watering facilities.

Continue to reduce erosion through implementation of no-till/direct seed, terraces, sediment basins, strip cropping, grassed waterways, and other BMPs.

Enhance instream flows by restoring riparian vegetation and improving soil infiltration with no-till/direct seed farming.

Enforce existing land use regulations including Critical Area Ordinances, Shoreline Management Act, and the Growth Management Act.

Inventory habitat conditions as well as fish presence and relative abundance on subbasin streams every five years to fill data gaps and monitor success of habitat restoration projects. Conduct continuous monitoring of water quality parameters such as water temperature and total suspended solids.

PALOUSE RIVER BELOW PALOUSE FALLS (WRIA 34) HABITAT LIMITING FACTORS

Palouse River below Palouse Falls Description (WRIA 34)

This reach of the Palouse River flows through a deep canyon cut through the Columbia River Basalts during the torrential Spokane Floods. Prior to these floods, the Palouse River flowed down the now abandoned Washtucna Coulee, joined Esquatzel Coulee at Connell, then joined the Columbia River near Pasco. The floods spilled over the south wall of the historic Palouse River valley and headed for the Snake River where the waters poured over the lip of the Snake River canyon. This was likely the original location of Palouse Falls. Successive flood flows produced immense whirlpools called “kolks” that tore large blocks of basalt from the face of the falls, causing the falls to erode upstream about six miles to its current location (Alt 2001). The Palouse Rive Canyon is up to 700 feet deep with basalt cliffs 200 to 300 feet high on either side of the stream (Marshall 1971). The Palouse Watershed drains portions of Whitman, Spokane, Adams, and Franklin Counties. Only the lower six miles of the Palouse River downstream from Palouse Falls will be evaluated in this report (See Map 1). Lake Herbert G. West (Lower Monumental Reservoir) has pooled water to about river mile 2.5 on the lower Palouse River. The remainder of WRIA 34 will not be evaluated because 185-feet high Palouse Falls blocks anadromous fish runs (USDA Soil Conservation Service *et al.* 1978) (See Figure 27).

The Palouse Tribe were the earliest inhabitants of the basin, living along the Palouse River from the falls downstream to the Snake River as far back as 10,000 years ago. Early settlers raised livestock and farmed enough bottomland to provide gardens and grain for family needs. In the early 1880s railroads and improved cultivation equipment made dryland farming profitable. The Palouse grasslands were rapidly transformed to fields of grains, sugar beets, and thousands of acres of orchards. Soil erosion was not a problem until people cultivated and destroyed soil structure with farm equipment. Field burning removed 80 to 95% of field residue, leaving no humus to build up the soil. From 1934 to 1978, nearly ¾ tons of soil were lost for every bushel of wheat produced in the basin. In 1978, sheet and rill erosion of cropland accounted for greater than 90% of soil erosion, contributing to a fine sediment load of 3-million tons per year. As of 1978, 1.23 million acres of the basin (58%) were used for cropland, while rangeland comprised 597,000 acres (28%) (USDA Soil Conservation Service *et al.* 1978). No towns or cities are located in the valley below Palouse Falls. Summer steelhead and fall chinook are known to be present in this reach of the Palouse River. Isolated sightings of bull trout have also been reported (Mendel 2001, personal communication) (See Appendix B).

Palouse River below Palouse Falls

Habitat Ratings

Fish Passage

Palouse Falls (RM 6) at about 185 feet in height (USDA Soil Conservation Service *et al.* 1978) is a complete barrier to anadromous fish passage.

Figure 27. Palouse Falls. Photographed May 2001.

Screens and Diversions

No irrigation diversions are present (Bumgarner 2002, personal communication).

Riparian Condition

Grasses and small shrubs are the primary vegetation along this reach. The high canyon walls are the primary source of shade in the canyon (Bumgarner 2002, personal communication). The sparse riparian vegetation is likely a natural condition.

Streambank Condition

Banks are composed of primarily large cobbles and bedrock with little active erosion taking place (Bumgarner 2002, personal communication).

Floodplain Connectivity

The river has full access to the floodplain (Bumgarner 2002, personal communication).

Width/Depth Ratio

The stream is generally wide and shallow, likely the result of large amounts of sediment deposition (Bumgarner 2002, personal communication).

Substrate Embeddedness

In late winter and early spring the Palouse River ran "thick and brown with approximately 3 million tons of precious topsoil (USDA Soil Conservation Service *et al.* 1978)." Substrate embeddedness is suspected to be substantial with the Palouse River carrying such a high fine sediment load. Washington Department of Fish and Wildlife personnel reported kicking up large clouds of fine sediment while walking in the stream channel during spawning ground surveys. Fall chinook have been observed spawning in this reach, but no information was available regarding spawning success (Bumgarner 2002, personal communication).

Large Woody Debris

Little woody debris is present (Bumgarner 2002, personal communication).

Pool Frequency

Some pools are present, but they generally represent < 5% (estimated) of stream surface area (Bumgarner 2002, personal communication).

Pool Quality

Where present pools are generally large and deep. Pools are often associated with scour along the basalt canyon walls (Bumgarner 2002, personal communication). Although pools are large, they typically have little instream or overhead cover and mud bottoms (Mendel 2002a, personal communication).

Off-Channel Habitat

No off-channel habitat is present (Bumgarner 2002, personal communication).

Water Quality/Temperature

No water temperature information was located for this reach.

Water Quantity/Dewatering

About one half million acre-feet per year of water flows out of the Palouse River Basin (USDA Soil Conservation Service *et al.* 1978).

Change in Flow Regime

The pool from Lower Monumental Dam has inundated the Palouse River to about RM 2.5.

Biological Processes

Grass pickerel are known to be present in this reach of the Palouse River (Wydoski and Whitney 1979). Channel catfish and other exotic fishes are also present (Mendel 2002a, personal communication). Reduced levels of marine-derived nutrients contributed by anadromous fish (i.e. eggs, juveniles, and decomposing carcasses) likely limit productivity (Mendel 2002a, personal communication).

PALOUSE RIVER BELOW PALOUSE FALLS RECOMMENDATIONS

Continue to reduce fine sediment deposition through implementation of no-till/direct seed, terraces, sediment basins, grassed waterways, strip cropping, and other BMPs.

Maintain the existing limited riparian buffer.

Inventory habitat conditions as well as fish presence and relative abundance every five years to fill data gaps and monitor success of habitat restoration projects. Conduct continuous monitoring of water quality parameters such as water temperature and total suspended solids.

SALMONID HABITAT CONDITION RATING STANDARDS FOR IDENTIFYING LIMITING FACTORS

Under the Salmon Recovery Act (passed by the legislature as House Bill 2496 (codified to RCW 77), and later revised by Senate Bill 5595), the Washington Conservation Commission (WCC) is charged with identifying the habitat factors limiting the production of salmonids throughout most of the state. This information should guide lead entity groups and the Salmon Recovery Funding Board in prioritizing salmonid habitat restoration and protection projects seeking state and federal funds. Identifying habitat limiting factors requires a set of standards that can be used to compare the significance of different factors and consistently evaluate habitat conditions in each WRIA throughout the state.

In order to develop a set of standards to rate salmonid habitat conditions, several tribal, state, and federal documents that use some type of habitat rating system (Table 8) were reviewed. The goal was to identify appropriate rating standards for as many types of habitat limiting factors as possible, with an emphasis on those that could be applied to readily available data. Based on the review, it was decided to rate habitat conditions into three categories: good, fair, and poor. For habitat factors that had wide agreement on how to rate habitat condition, the accepted standard was adopted by the WCC. For factors that had a range of standards, one or more of them were adopted. Where no standard could be found, a default rating standard was developed by WCC, with the expectation that it will be modified or replaced as better data become available.

Table 8. Salmonid Habitat Rating Criteria Source Documents.

Code	Document	Organization
Hood Canal	Hood Canal/Eastern Strait of Juan de Fuca Summer Chum Habitat Recovery Plan, Final Draft (1999)	Point No Point Treaty Council, Skokomish Tribe, Port Gamble S'Klallam Tribe, Jamestown S'Klallam Tribe, and Washington Department of Fish and Wildlife
ManTech	An Ecosystem Approach to Salmonid Conservation, vol. 1 (1995)	ManTech Environmental Research Services for the National Marine Fisheries Service, the US Environmental Protection Agency, and the US Fish and Wildlife Service
NMFS	Coastal Salmon Conservation: Working Guidance for Comprehensive Salmon Restoration Initiatives on the Pacific Coast (1996)	National Marine Fisheries Service
PHS	Priority Habitat Management Recommendations: Riparian (1995)	Washington Department of Fish and Wildlife
Skagit	Skagit Watershed Council Habitat Protection and Restoration Strategy (1998)	Skagit Watershed Council
WSA	Watershed Analysis Manual, v4.0 (1997)	Washington Forest Practices Board
USFWS Guidelines	A Framework to Assist in Making Endangered Species Act Determinations of Effect for Individual or Grouped Actions at the Bull Trout Subpopulation Watershed Scale	Fish and Wildlife Service
NMFS Criteria	Juvenile Fish Screen Criteria and the Addendum for Juvenile Fish Screen Criteria for Pump Intakes.	National Marine Fisheries Service
TAG 2001	Assessments of conditions are based on the professional knowledge and judgment of the Technical Advisory Group.	2496 Snake River Habitat Limiting Factors Technical Advisory Group (See Acknowledgements)
WSP	Wild Salmonid Policy (1997)	Washington Department of Fish and Wildlife

The ratings adopted by the WCC are presented in Table 9. These ratings are not intended to be used as thresholds for regulatory purposes, but as a coarse screen to identify the most significant habitat limiting factors in a WRIA. They will provide a level of consistency between WRIAs that allows habitat conditions to be compared across the state. However, where data is unavailable or where analysis of data has not been conducted, the professional expertise of the TAG is used. In some cases, there may be local conditions that warrant deviation from the rating standards presented here. Additional rating standards will be included as they become available and will supersede the standards used in this report.

Table 9. WCC Salmonid Habitat Condition Rating Criteria.

Habitat Factor	Parameter/Unit	Channel Type	Poor	Fair	Good	Source
Fish Passage	Man-made physical barriers	All SE Washington	Man-made barriers present in the reach restrict upstream and/or downstream fish passage at a range of flows.	Man-made barriers present in the reach restrict upstream and/or downstream fish passage at base/low flows.	Man-made barriers present in the reach allow adequate upstream and downstream fish passage at all flows.	USFWS Guidelines TAG 2001
Screens and Water Diversion Ditches	Water diversion structures, both gravity and pump	All SE Washington	Does not meet NMFS juvenile fish screen criteria.	Meets all NMFS criteria for juvenile fish screen except screen mesh size.	Meets NMFS juvenile fish screen criteria.	NMFS Juvenile Fish Screen Criteria and Addendum for Pump Intakes
Riparian Condition	Riparian corridors, wetlands, intermittent headwater streams, and other areas where proper ecological functioning is crucial to maintenance of the stream's water, sediment, woody debris and nutrient delivery systems (definition taken from PACFISH for riparian habitat conservation areas)	All SE Washington	Riparian areas are fragmented, poorly connected, or provide inadequate protection of habitats for sensitive aquatic species (<70% intact, refugia does not occur), and do not adequately buffer land use impacts; percent similarity of riparian vegetation to the potential natural community/composition is <25%.	Moderate loss of connectivity or function (shade, LWD recruitment, etc.) of riparian areas, or incomplete protection of habitats and refugia for sensitive aquatic species (≈ 70-80% intact) and adequately buffer land use impacts; percent similarity of riparian vegetation to the potential natural community/composition is 25-50% or better.	Riparian areas provide adequate shade, LWD recruitment, and habitat protection and connectivity in subwatersheds, and buffers or includes known refugia for sensitive aquatic species (>80% intact) and adequately buffer land use impacts; percent similarity of riparian vegetation to the potential natural community/composition is >50%.	USFWS Guidelines TAG 2001

Table 9. Continued.

Habitat Factor	Parameter/Unit	Channel Type	Poor	Fair	Good	Source
Streambank Condition	% of stream reach in stable natural condition	All SE Washington	<50% of any stream reach has ≥90% natural stability	50–80% of any stream reach has ≥90% natural stability	>80% of any stream reach has ≥90% natural stability	USFWS Guidelines TAG 2001
Floodplain Connectivity	Stream and off-channel habitat length with lost floodplain connectivity due to incision, roads, dikes, flood protection, or other	All SE Washington	Severe reduction in hydrologic connectivity between off-channel, wetland, floodplain and riparian areas; wetlands extent drastically reduced and riparian vegetation/succession altered significantly.	Reduced linkage of wetland, floodplains and riparian areas to main channel; overbank flows are reduced relative to historic frequency, as evidenced by moderate degradation of wetland function and riparian vegetation/succession.	Off-channel areas are frequently hydrologically linked to main channel; overbank flows occur and maintain wetland functions, riparian vegetation and succession.	USFWS Guidelines
Width/Depth Ratio	Ratio of Bankfull width to average bankfull depth (i.e. width divided by depth)	All SE Washington	>20 (example: 20' wide by 1' deep)	11-20 (example: 30' wide by 2' deep)	≤10 (example: 50' wide by 10' deep)	USFWS Guidelines TAG 2001
Substrate Embeddedness	Degree of substrate embeddedness in spawning and rearing areas	All SE Washington	>30%	20 – 30%	<20%	USFWS Guidelines TAG 2001
Large Woody Debris	Pieces/mile that are >12" in diameter and >35 ft. in length or stable at flows < 25 year event; also adequate sources of woody debris are available for both long and short-term recruitment within the channel migration zone (CMZ)	All SE Washington	Current levels are not at those desired values for "Good/Properly Functioning", and potential sources of woody debris for short and /or long term recruitment are lacking within the channel migration zone	Current values are being maintained at minimum levels desired for "Good/Properly Functioning", but potential sources for long-term woody debris recruitment are lacking within the channel migration zone to maintain these minimum values	Current values are being maintained at greater than 20 pieces/mile, >12" in diameter and >35 ft. in length or stable at flows < 25 year event; also adequate sources of woody debris are available for both long and short-term recruitment within the channel migration zone (CMZ)	USFWS Guidelines TAG 2001

Table 9. Continued.

Habitat Factor	Parameter/Unit	Channel Type	Poor	Fair	Good	Source
Pool Frequency	% wetted channel surface area comprising pools	All SE Washington	<20% surface area **or** Pools/mile equals:	20-40% surface area **or** Pools/mile equals:	>40% surface area **or** Pools/mile equals:	TAG 2001 PFC Working Group
		Wetted Width (ft)				
		0 to 5	<19.5	19.5 to 38	39	
		5 to 10	<30	30 to 59	60	
		10 to 15	<24	24 to 47	48	
		15 to 20	<19.5	19.5 to 38	39	
		20 to 30	<11.5	11.5 to 22	23	
		30 to 35	<9	9 to 17	18	
		35 to 40	<5	5 to 9	10	
		40 to 65	<4.5	4.5 to 8	9	
		65 to 100	<2	2 to 3	4	
Pool Quality	Majority of pools	All SE Washington	< 1' deep or little or no cover and lack of interstitial spaces	1-3' with some cover and some interstitial spaces	>3' deep and or with lots of surface or subsurface cover	TAG 2001
Off-channel Habitat	Area within the channel migration zone.	Reaches with average gradient <2% in SE Washington	Reach has no ponds, oxbows, backwaters, or other off-channel areas	Reach has <5 ponds, oxbows, backwaters, and other off-channel areas with cover per mile; and side-channel areas are generally high energy areas	Reach has >5 ponds, oxbows, backwaters, and other off-channel areas with cover per mile; and side-channels are low energy areas	USFWS Guidelines TAG 2001

Table 9. Continued.

Habitat Factor	Parameter/Unit	Channel Type	Poor	Fair	Good	Source
Temperature	degrees Celsius/ degrees Fahrenheit	All SE Washington	>15.6°C/ 60°F (spawning) or >21.1°C/ 70°F (migration and rearing) or For bull trout, 7-day average maximum temperature in a reach during the following life history stages: • >15°C/ 59°F (rearing) • <4°C or > 10°C/ <39°F or >50°F (spawning) • <1°C or >6°C/ 34°F or 43ºF (incubation) also temperatures in areas used by adults during migration regularly exceed 15ºC (59ºF) (thermal barriers present)	14-15.6°C/59-60°F (spawning) or 18.3-21.1°C/65-70°F (migration and rearing) or For bull trout, 7-day average maximum temperature in a reach during the following life history stages: • <4°C or >13-15ºC/ <39°F or >55º-59ºF (rearing) • <4°C or >10°C/ <39°F or 50°F (spawning) • <2°C or >6°C/ 36°F or 43ºF (incubation) also temperatures in areas used by adults during migration sometimes exceed 15ºC (59ºF)	10-14°C/50-59°F (spawning) or <21.1°C/65°F (migration and rearing) For bull trout, 7-day average maximum temperature in a reach during the following life history stages: • 4°-12ºC/ 39°- 54ºF (rearing) • 4° - 9ºC/ 39°-48°F (spawning) • 2°-5°C/ 36°-41ºF (incubation) also temperatures do not exceed 15ºC (59ºF) in areas used by adults during migration (no thermal barriers)	NMFS and USFWS Guidelines TAG 2001
Water Quantity/ Dewatering	Presence/absence in a stream reach	All SE Washington	No flows during some portion of the year or inadequate for all lifestages	Inadequate flows for some lifestages during some portion of the year	Adequate flows for all lifestages present year-round	TAG 2001

Table 9. Continued.

Habitat Factor	Parameter/Unit	Channel Type	Poor	Fair	Good	Source
Change in Flow Regime	Change in Peak/Base Flows	All SE Washington	Pronounced changes in peak flow, base flow and/or flow timing relative to an undisturbed watershed of similar size, geology and geography	Some evidence of altered peak flow, base flow and/or flow timing relative to an undisturbed watershed of similar size, geology and geography	Watershed hydrograph indicates peak flow, base flow and flow timing characteristics comparable to an undisturbed watershed of similar size, geology and geography	USFWS Guidelines
Biological Processes	Lack of nutrient input from spawners, exotic species present, etc…	All SE Washington	No anadromous carcasses and there is likely exotic species competition	Few anadromous carcasses or there is exotic species competition	Many anadromous carcasses and no exotic species	TAG 2001

SALMONID HABITAT ASSESSMENT BY STREAM REACH

The narrative descriptions for each of the six subbasins discussed earlier in this report were compared to the rating criteria found in Table 9 to assess salmonid habitat conditions across the Middle Snake Watershed and the Palouse River below Palouse Falls. Each reach discussed in the report has a corresponding assessment in Table 10. Biological processes received a maximum rating of FAIR because of a nearly uniform lack of anadromous fish carcasses and depressed beaver populations throughout the watershed. Ratings in the "Water Quality/Temperature" column were based on water temperatures only. Very little information was available on other water quality issues such as chemical pollution, sewage effluent, dissolved oxygen levels, etc. Reaches that received a poor rating were identified as habitat limiting factors in Table 11. This table also attempts to identify probable causes for the poor habitat conditions.

Table 10. Salmonid Habitat Assessment by Stream Reach.

Key:

P = Average habitat condition considered poor (Not Properly Functioning)

F = Average habitat condition considered fair (At Risk)

G = Average habitat condition considered good (Properly Functioning)

1= Quantitative studies or published reports documenting habitat condition

2 = Professional knowledge of the WRIA 33, 34, 35 TAG members

S = Suspected

DG = Data Gap: habitat on the stream or reach has not been evaluated; TAG members had little or no knowledge of habitat conditions. The parameter was not rated.

NB = Natural Barrier

NAT = Natural

N/A = Not Applicable

N/E = Not Evaluated

= Bull trout juvenile (fry) rearing temperatures used for assessment

Stream Name	Fish Passage	Screens & Diversions	Riparian Condition	Streambank Condition	Floodplain Connectivity	Width/ Depth Ratio	Substrate Embed.	LWD	Pool Freq.	Pool Qual.	Off-channel Habitat	Water Quality/ Temperature	Water Quantity/ Dewatering	Change in Flow Regime	Biological Processes
Grande Ronde Subbasin															
Grande Ronde: WA portion	G2	DG	F2	P2	F2	F2	SP2	SP2	DG	DG	F2	P1	F2	F2	P1
Grande Ronde Tribs: WA portion	SF2	DG	F2	DG	N/A	P1	F2-G1[a]	G1	P1[a]	G1[a]	G1[a]	F1[b]-G1[a]	DG	G2	F2
Wenaha River Tribs: within WA	G1	N/A	F1-G1	G1	N/A	G1	F1-G1	G1	P1	F1-G1	N/A	F2-G2	G1	G1	F2
Tenmile-Couse Subbasin															
Couse Creek	P1	DG	F1	P1-F1	F1-G1	F1-G1	P1	P1	P1	P1	N/A	P1	P1	G1	F2
Tenmile Creek: Headwaters to Mill Creek	P1	DG	F1-G1	P1-F1	N/A	F2-P2	F1-P1	P2	DG	DG	N/A	P1	P1	F2	F2
Tenmile Creek: Mill Creek to mouth	P2	DG	P1	P1	F1	P1	F1-P1	P1	P1	P1	F1	P1	P1	F2	F2

Notes: (a) USFS portion of Menatchee Creek only. (b) Lower Joseph Creek.

Table 10. Continued.

Stream Name	Fish Passage	Screens & Diversions	Riparian Condition	Streambank Condition	Floodplain Connectivity	Width/ Depth Ratio	Substrate Embed.	LWD	Pool Freq.	Pool Qual.	Off-channel Habitat	Water Quality/ Temperature	Water Quantity/ Dewatering	Change in Flow Regime	Biological Processes
Asotin Subbasin															
North Fork Asotin Creek	G1	N/A	F1-G1	G1[c]-P1[d]	G1	G1	P1-G1	G1	P1-G1	F1	N/A	G2	G1[c]-P1[d]	G2	F2
South Fork Asotin Creek	G2	DG	F2-G2	F2	F2	G1	G1	F1-G1	F1	P1	F2	F1	F2-G2	G2	F2
Asotin Creek: Forks to George Creek	F2	DG	P1	G1	P2	F2-P2	G1	F2-P2	G1	P1	F2	F1	G2	F2	F2
Asotin Creek: George Creek to mouth	G2	DG	P2	P2	P2	P2	SP1,2	P2	DG	P2	P2	P1	DG	F1	F2
Charley Creek	DG	DG	P1-F2	P1-F2	P1	G1	F1-G1	F1	F1	P1	P2	G1	G2	G1	F2
George Creek: Headwaters to Wormell Creek	F1	N/A	G1	F1-G1	N/A	F1	F1	G1	P1	F1	G1	G1	G1	G1	F2
George Creek: Wormell Creek to mouth	F1	DG	P1-G1	P1-G1	G1	P1	F1	P1	P1	P1	F1	P1	P1	P1	F2
Pintler Creek	F2	N/A	F2-G2	F2-G2	G2	F1	P1	F2	F2	F1	N/A	P1	P1	DG	F2
Alpowa-Deadman Subbasin															
Alpowa Creek: Headwaters to Stember Creek	G2	DG	P1-F2	P1	F2	F2	P1	P1	P1	P2	P1	P1	G1	P2	F2
Alpowa Creek: Stember Creek to mouth	G1	G2	F2	G1	F2	F1	P1	P1	P1	P2	F2	P1	DG	DG	F2

Notes: (c) North Fork Asotin Creek. (d) Lick Creek.

Table 10. Continued.

Stream Name	Fish Passage	Screens & Diversions	Riparian Condition	Streambank Condition	Floodplain Connectivity	Width/ Depth Ratio	Substrate Embed.	LWD	Pool Freq.	Pool Qual.	Off-channel Habitat	Water Quality/ Temperature	Water Quantity/ Dewatering	Change in Flow Regime	Biological Processes
Alpowa-Deadman Subbasin Cont'd.															
Meadow Creek	P1	DG	P1	P1	P1	F1	P1	P1	P1	P1	P1	F1	P1	DG	DG
North and South Deadman Creeks	DG	DG	P1	P1[e]-G1[f]	P1	G1	F1-P1	P1	P1	P1	P1	P1	F2	DG	F2
Deadman Creek: Forks to mouth	P1	DG	P1	P1	P2	G1	P1	P1	P1	P1	F1	P1	F2	DG	F2
Tucannon Subbasin															
Tucannon River: Headwaters to Panjab Creek	G1	N/A	G1	G1	G1	G1	G1,2	G1	P1-G2	F1	F2	G1	G1	G1	F2
Tucannon River: Panjab Creek to Marengo	F2	DG	P1-G1	F1-P1	F1	G1	F1	G1	P1	P1	DG	F1	G1	DG	F2
Tucannon River: Marengo to U.S. Hwy. 12	F2	DG	P1	P1	P1	DG	G2	DG	DG[g]	DG	DG	F1	DG	DG	F2
Tucannon River: U.S. Hwy. 12 to mouth	F2	DG	P1	P1	P1	DG	G2	DG	DG[g]	DG	DG	P1	F1-G1	DG	P1

Notes: (e) North Deadman Creek. (f) South Deadman Creek. (g) Although data were available, they were collected prior to the 1996-97 floods; therefore, the data were not seen as representative of current conditions.

Table 10. Continued.

Stream Name	Fish Passage	Screens & Diversions	Riparian Condition	Streambank Condition	Floodplain Connectivity	Width/ Depth Ratio	Substrate Embed.	LWD	Pool Freq.	Pool Qual.	Off-channel Habitat	Water Quality/ Temperature	Water Quantity/ Dewatering	Change in Flow Regime	Biological Processes
Tucannon Subbasin Cont'd.															
Pataha Creek: Headwaters to Columbia Center	P2	DG	F1	P1	F2	G1	P1	F2-G1	F1	P1	P2	F1	DG	G2	P1
Pataha Creek: Columbia Center to Pomeroy	P1	DG	P1	P2	G2	DG	P1	P2	G1	DG	DG	DG	DG	DG	P1
Pataha Creek: Pomeroy to mouth	P1	DG	P1	P1	P1	DG	P1	SP2	P1	DG	DG	P1	DG	DG	F2
Snake Subbasin															
Steptoe Creek	P2	DG	P1	P1	F2-P1	F1-G1	P1	P1	P1	P1	N/A	P1	P2	DG	F2
Wawawai Creek	P1	DG	F1	DG	F2	F1	DG	DG	DG	DG	N/A	F1	P2-F2	DG	F2
Almota Creek	G1	DG	F1	P1	F1	F1-G1	P1	P1	P1	P1	N/A	P1	F2	DG	F2
Little Almota Creek	P1	DG	P1-G1	P1-F2	N/A	F1-G1	P1	P1	P1	P1	N/A	P1	P1	DG	DG
Penawawa Creek	DG	DG	DG	DG	DG	DG	DG	DG	DG	DG	DG	DG	DG	DG	DG
Alkali Flat Creek	DG	DG	DG	DG	DG	DG	DG	DG	DG	DG	DG	DG	DG	DG	DG
Palouse River below Palouse Falls	G1	DG	G2	G2	G2	P2	P2	P2	P2	F2	P2	DG	G2	DG	P1

HABITAT LIMITING FACTORS, POTENTIAL CAUSES, AND RECOMMENDATIONS

Reaches that received a poor rating in Table 10 were identified as habitat limiting factors in Table 11. This table also attempts to identify probable causes for the poor habitat conditions. Prioritized recommendations to improve habitat conditions are included as well.

Table 11. Habitat Limiting Factors, Potential Causes, and Recommendations

Habitat Limiting Factor	**Stream Reach (Rated Poor in** Table 10**)**	**Potential Human-Induced Causes (In order of significance)**	**Recommendations (In order of priority)**
Fish Passage	4-6, 17, 19, 24-28, 30	Diversion Dams (concrete and gravel push-ups) Failed culverts Grade control structures Road Fords	1. Install fish passage structures 2. Replace push-up dams with structures that provide passage 3. Replace failed culverts 4. Replace fords with bridges, or decommission
Screens & Diversions	Data Gap	Unscreened Diversions Existing screens do not meet state or federal criteria	1. Conduct comprehensive basin-wide inventory of surface water diversions to ensure that all diversions are properly screened
Riparian Condition	6, 9-11, 13, 15, 17-19, 21- 23, 25-27, 30	Conversion to cropland Residential development Grazing & Logging Concentrated recreational use of public lands	1. Enforce land use regulations 2. Fence livestock out of riparian zones 3. Replant native riparian vegetation 4. Relocate campsites or trails to less sensitive areas
Bank Condition	1, 4-7, 10-13, 15, 17-19, 21-27, 29, 30	Removal of riparian vegetation Channel modifications including: dikes, riprap, bridges, channel relocation, and culverts	1. Remove or setback dikes, remove riprap 2. Restore meandering channel geometry 3. Replant native riparian vegetation
Floodplain Connectivity	9-11, 17-19, 22, 23, 26, 27	Construction of dikes and levees Channel modifications including: straightening and riprap Conversion of wetlands to cropland	1. Enforce land use regulations 2. Remove or setback dikes, remove riprap 3. Restore meandering channel geometry
Width/Depth Ratio	2, 5, 6, 9, 10, 13, 31	Unstable streambed and banks caused by removal of riparian vegetation and channel modifications	1. Restore meandering channel geometry 2. Replant native riparian vegetation
Substrate Embeddedness	1, 4-7, 10, 14-19, 24-27, 29-31	Fine sediment eroded from croplands and roads Fine sediment eroded from forest lands and roads Fine sediment eroded from unstable banks	1. Convert from conventional tillage to no-till/direct seed farming methods 2. Decommission dirt roads 3. Replant native riparian vegetation
Large Woody Debris	1, 4-6, 9, 10, 13, 15-19, 25-27, 29-31	Removal of wood from stream channels Removal of large trees in riparian zone Dikes and levees restrict access to riparian vegetation	1. Place LWD in spawning and rearing reaches 2. Restore meandering channels 3. Leave LWD in channels and replant native riparian vegetation
Pool Frequency	2-4, 6, 7, 12, 13, 15-21, 26, 27, 29-31	Lack of large woody debris Channel modifications including: dikes, riprap, bridges, channel relocation and culverts	1. Place LWD in spawning and rearing reaches 2. Restore meandering channel geometry 3. Leave LWD in channels and replant native riparian vegetation
Pool Quality	4, 6, 8-11, 13, 15-19, 21, 24, 27, 29, 30	Lack of large woody debris Channel modifications including: dikes, riprap, bridges, channel relocation and culverts	1. Place LWD in spawning and rearing reaches 2. Restore meandering channel geometry 3. Leave LWD in channels and replant native riparian vegetation
Off-channel Habitat	10, 11, 15, 17, 18, 24, 31	Construction of dikes and levees Channel modifications including: channel modification, riprap Conversion of wetlands to cropland	1. Enforce land use regulations 2. Remove or setback dikes, remove riprap 3. Replant native riparian vegetation
Water Quality/ Temperature	1, 4-6, 10, 13-16, 18, 19, 23, 26, 27, 29, 30	Naturally low summer stream flows exacerbated by irrigation water withdrawals and high air temperatures Lack of riparian vegetation to provide shade	1. Increase summer instream flows 2. Replant native riparian vegetation

Table 11. Continued.

Habitat Limiting Factor	**Stream Reach (Rated Poor in** Table 10**)**	**Potential Human-Induced Causes (In order of significance)**	**Recommendations (In order of priority)**
Water Quantity/ Dewatering	4-7, 13, 14, 17, 27, 28, 30	Naturally low summer stream flows exacerbated by irrigation water withdrawals and high air temperatures	1. Increase summer instream flows 2. Restore floodplain connectivity 3. Reduce surface water losses on losing reaches
Change in Flow Regime	13, 15	Surface water withdrawals, logging, channel modifications	1. Increase summer instream flows 2. Restore meandering channel geometry
Biological Processes	1, 23-25, 31	Introductions of exotic plants and animals, extinction of native spring chinook, trapping of beaver	1. Eradicate exotic fish and riparian plant species 2. Seed upper watersheds with hatchery carcasses 3. Allow beaver populations to rebuild

Key to Reach Numbers:

1. Grande Ronde River Mainstem (within Washington)
2. Grande Ronde River Tributaries (within Washington)
3. Wenaha River Tributaries (within Washington)
4. Couse Creek
5. Tenmile Creek: Headwaters to Mill Creek
6. Tenmile Creek: Mill Creek to mouth
7. North Fork Asotin Creek
8. South Fork Asotin Creek
9. Asotin Creek: Forks to George Creek
10. Asotin Creek: George Creek to mouth
11. Charley Creek
12. George Creek: Headwaters to Wormell Creek
13. George Creek: Wormell Creek to mouth
14. Pintler Creek
15. Alpowa Creek: Headwaters to Stember Creek
16. Alpowa Creek: Stember Creek to mouth
17. Meadow Creek
18. North and South Deadman Creeks
19. Deadman Creek: Forks to mouth
20. Tucannon River: Headwaters to Panjab Creek
21. Tucannon River: Panjab Creek to Marengo
22. Tucannon River: Marengo to U.S. Hwy. 12
23. Tucannon River: U.S. Hwy. 12 to mouth
24. Pataha Creek: Headwaters to Columbia Center
25. Pataha Creek: Columbia Center to Pomeroy
26. Pataha Creek: Pomeroy to mouth
27. Steptoe Creek
28. Wawawai Creek
29. Almota Creek
30. Little Almota Creek
31. Palouse River below Palouse Falls

CURRENT SALMONID HABITAT RESTORATION EFFORTS AND RECOMMENDATIONS FOR FURTHER ACTION

Current Salmonid Habitat Restoration Efforts

Soil Erosion

The "Habitat Limiting Factors by Subbasin" narratives describe a somewhat bleak picture of salmonid habitat conditions in WRIAs 33, 34, and 35, but efforts are currently underway to address many of the limiting factors identified on Snake River tributary streams. Asotin County Conservation District, Pomeroy Conservation District, Columbia Conservation District, Palouse Conservation District, USDA Natural Resources Conservation Service (NRCS), and Washington State University Cooperative Extension (WSU Extension) are working to encourage dryland farmers to implement best management practices (BMPs) that reduce soil erosion. These practices include no-till/direct seed farming methods (direct seeding into standing wheat stubble for example); installation of terraces, sediment basins, and vegetated filter strips; and enrollment of acreage in the Conservation Reserve Program (CRP, conversion of annual cropland to perennial grass stands for wildlife habitat benefits). Numerous projects that reduce soil erosion from cropland have been implemented in Asotin, Whitman, Garfield, and Columbia Counties (Palouse Conservation District 1995, Northwest Power Planning Council 2001a, Northwest Power Planning Council 2001c, Northwest Power Planning Council 2001e) (See Table 12).

These efforts have improved habitat conditions to some extent, but considerable additional progress toward erosion reduction is needed, especially in the Pataha, Deadman, Meadow, and George Creek watersheds. These streams carry extremely high fine sediment loads following storm events in summer, fall, and winter. Conversion from conventional tillage to no-till/direct seed farming methods requires more than a change in management practices. It often requires substantial investments of capital in new equipment. Many producers are reluctant to make the transition because of cost and skepticism about the economic viability of no-till/direct seed farming methods. Efforts should continue to educate producers about the costs and benefits of no-till/direct seed farming along with financial assistance programs that lessen the cost of conversion.

Riparian Buffers

The Conservation Districts (CDs) and NRCS are addressing riparian zone problems with the Conservation Reserve Enhancement Program (CREP). The program is intended to restore riparian forest buffers on agricultural lands adjacent to salmonid bearing streams. The Conservation Reserve Program (CRP) is available through the NRCS to landowners wishing to restore riparian buffers along non-salmonid producing streams. Livestock is fenced out of the buffer and native vegetation is planted. Landowners are compensated at 200% of the agricultural value of the land placed in the buffer over a 10 to 15-year rental agreement. The program pays for all plant materials, fencing, and alternate livestock watering facilities. Currently Asotin County CD is improving 20.4 miles of riparian buffers (Johnson 2001, personal communication). Pomeroy CD (Garfield County) is improving 25 miles of buffers (Bartels 2002, personal communication). As of January 2002, Columbia CD is improving 23.9 miles of buffers along the Tucannon River (Nordheim 2002, personal communication) (See Table 12).

A mature riparian forest does not spring up overnight, making restoration and realization of the associated benefits a long-term process. Dry summers, incised or unstable stream channels, low water tables, and weed competition will likely make riparian restoration difficult. Supplemental watering of young vegetation will be necessary. Where possible, landowners with water rights to irrigate crops on the land converted to riparian buffer should be encouraged to use the water right to irrigate the buffer. In essence, the landowner is being paid to grow a riparian buffer rather than an irrigated crop such as alfalfa; therefore, they should make every effort to ensure that the crop (i.e., riparian vegetation) flourishes. Some stream reaches have very unstable stream banks. Portions of the Tucannon River and Couse Creek are examples of this condition. In these areas some instream work (bioengineering) will likely be needed to stabilize banks long enough to prevent channel migration that will destroy young plantings. However, this should not be used as a justification to armor banks for flood control purposes under the guise of salmonid habitat restoration.

The WRIA 33, 34, 35 technical advisory group (TAG) has recommended that riparian restoration projects be targeted as far upstream as possible. This will provide the most benefit by keeping water cool and conveying it downstream, rather than attempting to cool water onsite after temperatures have exceeded the tolerance levels of salmonids. This philosophy is especially important when project funding is obtained through a competitive process such as Salmon Recovery Funding Board (SRFB) monies. Ideally BPA and CREP funded projects should be targeted with this strategy as well, but if eligible land and willing landowners are not present in the upper reaches of a stream, riparian buffers should be implemented where possible downstream.

<u>Instream Habitat</u>

Many Snake River tributary streams lack complex instream habitat in the form of large deep pools and instream cover including: large woody debris, overhanging vegetation, or large rocks. Southeast Washington tributary streams are generally “flashy,” potentially limiting the effectiveness and longevity of instream projects. Projects should be restricted to locations identified by technical experts. Reliance on instream work should be minimized since it often treats symptoms, rather than addressing the root cause(s) of habitat degradation. The conservation districts (CDs) have been working to improve habitat since the mid-1990s (Palouse Conservation District 1995, Northwest Power Planning Council 2001a, Northwest Power Planning Council 2001c, Northwest Power Planning Council 2001e) (See Table 12).

Table 12. Salmonid habitat improvement projects implemented from 1995 to 2001.

Data Sources: Deadman and Alpowa Creek Watersheds: (Northwest Power Planning Council 2001c). Tucannon River and Pataha Creek Watersheds: (Nordheim 2001, personal communication, Northwest Power Planning Council 2001e, Mendel 2002a, personal communication). Asotin Creek Watershed: (Northwest Power Planning Council 2001a). Tenmile/Couse Creek and Grande Ronde River Watersheds (Johnson 2001, personal communication). Snake River Tributaries: (Palouse Conservation District 1995).
Key: *BPA* = Bonneville Power Administration, *CD* = Conservation District, *CRP* = Conservation Reserve Program, *CREP* = Conservation Reserve Enhancement Program, *EQIP* = Environmental Quality Incentives Program, *FSA* = USDA Farm Service Agency, *LSRCP* = Lower Snake River Compensation Plan, *USFS, PRD* = US Forest Service, Pomeroy Ranger District, *SRFB* = Washington State Salmon Recovery Funding Board, *WCC* = Washington State Conservation Commission, *WDNR* = Washington Department of Natural Resources

Watershed	Project Sponsor (Funding Source)	Project Type	Project Size/No. (Year)	Project Description
Deadman Creek Watershed				
Deadman	Pomeroy CD (BPA)	Deep Fall Subsoiling	6,956 acres from (1996 to 1999)	Improves water infiltration into soil. Estimated prevention of **28,606 tons** of soil erosion.
Deadman	Pomeroy CD (BPA)	No-till/direct seed Seeding	8,071 acres from (1996 to 2000)	Stabilizes soil and improves water infiltration. Estimated prevention of **47,552 tons** of soil erosion.
Deadman	Pomeroy CD (BPA)	Sediment Basins	70,509 cubic yards from (1996 to 2000)	Eroded soil is washed into the basin where it settles out of the water Estimated prevention of **3,891 tons** of soil erosion.
Deadman	Pomeroy CD (BPA)	Grass in Rotation	180 acres from (1996 to 2000)	Stabilizes soil and improves water infiltration. Estimated prevention of **1,649 tons** of soil erosion.
Deadman	Pomeroy CD (BPA)	Grassed Waterways	54,740 feet from (1996 to 2000)	Filters soil from water. Estimated prevention of **2,219 tons** of soil erosion.
Deadman	Pomeroy CD (BPA)	Terraces	210,181 feet from (1996 to 2000)	Channels water along long slope of hill, reducing erosion. Estimated prevention of **24,774 tons** of erosion.
Deadman	Pomeroy CD (BPA)	2-pass Seeding	4,472 acres from (1996 to 2000)	Causes less soil disturbance than conventional tillage. Estimated prevention of **19,209 tons** of erosion.
Alpowa Creek Watershed				
Alpowa	Pomeroy CD (BPA)	No-till/direct seed Seeding	1,647 acres from (1996 to 2000)	Stabilizes soil and improves water infiltration. Estimated prevention of **13,505 tons** of soil erosion.
Alpowa	Pomeroy CD (BPA)	Sediment Basins	46,177 acres from (1996 to 1999)	Eroded soil is washed into the basin where it settles out of the water Estimated prevention of **2,742 tons** of soil erosion.
Alpowa	Pomeroy CD (BPA)	Grassed Waterways	10,825 feet in (1996)	Filters soil from water. Estimated prevention of **634 tons** of soil erosion.

Table 12. Continued.

Watershed	Project Sponsor (Funding Source)	Project Type	Project Size/No. (Year)	Project Description
Alpowa	Pomeroy CD (BPA)	Terraces	59,903 feet from (1996 to 2000)	Channels water along long slope of hill, reducing erosion. Estimated prevention of **8,614 tons** of erosion.
Alpowa	Pomeroy CD (BPA)	Upland Fencing	3,218 feet in (1997)	Keeps livestock out of drainage areas. Estimated prevention of **500 tons** of erosion.
Alpowa	Pomeroy CD (BPA)	Deep Fall Subsoiling	449 acres from (1998 to 1999)	Improves water infiltration into soil. Estimated prevention of **1,142 tons** of soil erosion.
Alpowa	Pomeroy CD (BPA)	Strip Cropping	124 acres in (1998)	Filters soil from runoff. Estimated prevention of **248 tons** of erosion.
Alpowa	Pomeroy CD (BPA)	Streambank Protection	150 feet in (2000)	Protected eroding banks. Estimated prevention of **48 tons** of erosion.
Alpowa	Pomeroy CD (BPA)	Fish Barrier Removal	3 removed in (2000)	Removed concrete irrigation dams on lower Alpowa Creek and installed 1 consolidated properly screened diversion.
		Tucannon River Watershed		
Tucannon	Columbia CD (BPA & SRFB)	Large Pools	84	Installed from 1996 to 2001.
Tucannon	Columbia CD (BPA & SRFB)	Habitat Complexity/LWD	29,764 ft.	Installed from 1996 to 2001.
Tucannon	Columbia CD (BPA & SRFB)	Off-channel Habitat	7	Installed from 1996 to 2000.
Tucannon	Columbia CD (BPA & SRFB)	Small to Medium Pools	615	Installed from 1996 to 2001.
Tucannon	Columbia CD (BPA & SRFB)	Irrigation Modifications	2	Installed in 1996 and 1999.
Tucannon	Columbia CD (BPA & SRFB)	Riparian Fencing	20,753 ft.	Installed from 1996 to 1998.
Tucannon	Columbia CD (BPA & SRFB)	Trees/shrub planting	196,826	Planted from 1996 to 2001.
Tucannon	Columbia CD (BPA & SRFB)	No-till/direct seed Farming	1,400 acres	Cost-shared in 1999 and 2000.
Tucannon	Columbia CD (WCC & FSA)	CREP Riparian Buffer	168.5 acres	Enrolled in 2000.

Table 12. Continued.

Watershed	Project Sponsor (Funding Source)	Project Type	Project Size/No. (Year)	Project Description
Tucannon	WDFW	Sediment Basin		Installed sediment basin at the bottom of Hartsock Grade.
Tucannon	WDFW	Instream		Installed engineered logjam near Hartsock Grade.
Tucannon	WDFW Columbia CD Asotin CD	Riparian	(2000)	Established a cooperative native plant nursery near Hartsock Grade on WDFW land.
Tucannon	WDFW	Riparian		Moved most Wooten Wildlife Area campgrounds away from the Tucannon River.
Tucannon	WDFW	Riparian		Used WHIP and other funds to rip soil and replant native vegetation at old campground sites.
Tucannon	WDFW (LSRCP & USACE)	Instream	(1979 to 1985)	Constructed instream habitat on the Wooten Wildlife Area (eg. Mendel and Ross 1988).
Tucannon	WDFW	Screening		Improved screens and outlets on some of the Tucannon manmade lakes to exclude fish and reduce outflow temperatures.
Pataha Creek Watershed				
Pataha	Pomeroy CD (BPA)	Channel Restoration	1,200 ft.	Installed in 1996
Pataha	Pomeroy CD (BPA & SRFB)	Deep Fall Subsoiling	5,802 acres from (1996 to 2000)	Improves water infiltration into soil.
Pataha	Pomeroy CD (BPA & SRFB)	No-till/direct seed Farming	8,876 acres from (1996 to 2000)	Improves water infiltration into soil and holds soil in place.
Pataha	Pomeroy CD (BPA & SRFB)	Critical Area Seeding	22 acres from (1996 to 1998)	Reduces erosion in damaged areas.
Pataha	Pomeroy CD (BPA)	Divided Slope Farming	163 acres in from (1996 to 1998)	Filters soil from runoff.
Pataha	Pomeroy CD (BPA)	Riparian/Upland Buffers	87.7 acres from (1996 to 1999)	Filters runoff, in the future will stabilize banks, and provide shade and LWD.
Pataha	Pomeroy CD (BPA)	Strip Cropping	883 acres	Filters soil from runoff.
Pataha	Pomeroy CD (BPA)	Stream Improvement	1,600 ft. from (1996 to 1998)	

Table 12. Continued.

Watershed	Project Sponsor (Funding Source)	Project Type	Project Size/No. (Year)	Project Description
Pataha	Pomeroy CD (BPA)	Terraces & Waterways	48 miles from (1996 to 1999)	Channel water along the long slope of a hill, reducing erosion.
Pataha	Pomeroy CD (BPA & SRFB)	Tree Planting	49,900 trees	Installed from 1996 to 2000.
Pataha	Pomeroy CD (BPA & SRFB)	Grass in Rotation	337 acres from (1997 to 2000)	Reduces erosion by establishing plant cover.
Pataha	Pomeroy CD (BPA)	Off-site Watering	31,716 ft. of pipe and 3 watering sites	Installed from 1997 to 1998.
Pataha	Pomeroy CD (BPA)	2-Pass Seeding	3,961 acres from (1998 to 2000)	Reduces the number of tillage operations, thereby reducing erosion.
Pataha	Pomeroy CD (BPA & SRFB)	Riparian Fencing	9,000 ft. in (2000)	Prevents livestock access in the riparian buffer, thereby protecting vegetation and stream banks.
*Projects in the Pataha Creek Watershed prevented an estimated **112,960 tons** of soil erosion from 1996 to 2000.*				
Asotin Creek Watershed				
Asotin	Asotin County CD (BPA)	Watering Troughs	(1994)	Project Number: 199401804
Asotin	Asotin County CD (BPA)	Early Action Project	(1996)	Project Number: 199605800
Asotin	Asotin County CD (BPA)	Upland Sediment Reduction	(1997)	Project Number: 199708000
Asotin	Asotin County CD (BPA)	Upland BMPs	(1997)	Project Number: 199708600
Asotin	Asotin County CD (BPA)	Lick Creek Water Gap	(1997)	Project Number: 199708700
Asotin	Asotin County CD (BPA)	Riparian Fencing/Rock Blasting	(1997)	Project Number: 199709900
Asotin	Asotin County CD (BPA)	Woody Materials	(1998)	Project Number: 199804400
Asotin	Asotin County CD (BPA)	Fish Structure Monitoring	(1998)	Project Number: 199804500

Table 12. Continued.

Watershed	Project Sponsor (Funding Source)	Project Type	Project Size/No. (Year)	Project Description
Asotin	Asotin County CD (BPA)	Channel and Riparian Restoration	(1998)	Project Number: 199804600
Asotin	Asotin County CD (BPA)	Information and Education	(1998)	Project Number: 199804700
Asotin	Asotin County CD (BPA)	Project Implementation	(1999)	Project Number: 199900200
Asotin	Asotin County CD (BPA)	Five-Year Minimum Till Program	(1999)	Project Number: 199905200
Asotin	Asotin County CD (BPA)	Instream Project Monitoring	(1999)	Project Number: 199905400
Asotin	Asotin County CD (BPA)	Channel Restoration	(1999)	Project Number: 199905500
Asotin	Asotin County CD (BPA)	Yellow star thistle Control	(2000)	Project Number: 200000800
Asotin	Asotin County CD, Columbia CD, WDFW (BPA)	Native Tree Nursery	(2000)	Project Number: 200003200
Asotin	Asotin County CD (BPA)	GIS Mapping of Habitat Projects	(2000)	Project Number: 200004700
Asotin	Asotin County CD (BPA)	Riparian Planting	(2000)	Project Number: 200005300
Asotin	Asotin County CD (BPA)	Riparian Fencing	(2000)	Project Number: 200005400
Asotin	Asotin County CD (BPA)	Channel & Floodplain Restoration	(2000)	Project Number: 200006700
Asotin	Asotin County CD (SRFB)	Riparian Fencing and 5-year Direct Seeding	1,579 acres of Direct Seed	Implemented in 1999
Asotin	WDFW (LSRCP)	Monitor spring chinook and steelhead populations	(1980 to 2001)	
Asotin	USFS, PRD	Multiple Projects	(1998)	Road obliteration, tree planting, fencing, prescribed burns, habitat restoration

Table 12. Continued.

Watershed	Project Sponsor (Funding Source)	Project Type	Project Size/No. (Year)	Project Description
Asotin	USDA	CRP EQIP	20,989 acres 1,592 acres	
Asotin	Asotin County CD (WCC)	Multiple projects	(1996 to 2001)	
Asotin	Asotin County CD (2496 block grant)	Multiple projects	(1998)	
Asotin	Asotin County CD (WCC/FSA)	CREP Buffers	102.7 acres	
Asotin	WDFW	Instream	(1983 to 1986)	Constructed instream structures on State and Asotin County Park lands (eg. Viola *et al.* 1991).
		Tenmile/Couse Creek Watershed		
Couse	Asotin County CD/NRCS (WCC/FSA)	CREP Buffers CRP	117 acres 2,300 acres	
Tenmile	Asotin County CD/NRCS (WCC/FSA)	CRP	3,500 acres	
		Grande Ronde River Watershed		
Grande Ronde	Asotin County CD (WCC/FSA)	CREP Buffers	200 acres	
		Snake River Tributary Streams		
Middle Snake	Palouse CD (WDNR)	Spring Development	14 (1995)	Springs were developed to provide livestock with water at sites away from streams.
Middle Snake	Palouse CD (WDNR)	Cross Fencing	11.4 miles (1995)	Cross fencing allows producers to rotate pastures, improving forage production and plant health.
Middle Snake	Palouse CD (WDNR)	Sediment Basins	6,800 cubic yards (1995)	Sediment basins act as settling ponds, filtering fine sediment from runoff.
Middle Snake	Palouse CD (WDNR)	Terraces	43,400 ft. (1995)	Terraces direct runoff along the long slope of a hillside, reducing erosion.

DATA GAPS

The majority of available habitat information was collected prior to the 1996-97 floods. These data may not accurately reflect current conditions. An inventory of habitat conditions as well as fish presence and relative abundance should be undertaken every five years to fill data gaps and monitor success of habitat restoration projects.

Continuous water temperature and total suspended solids data are lacking throughout southeast Washington. Data collection should be expanded to establish baseline conditions and monitor the success of future habitat restoration efforts.

Little information exists regarding the number of surface water diversions currently in service, the amount of water they are withdrawing, or their compliance with state and federal screening regulations. An inventory of all surface water diversions should be undertaken to answer these questions.

Habitat conditions on Penawawa and Alkali Flat Creeks have not been assessed.

HABITAT TO PROTECT

Grande Ronde Subbasin

Streams in the Wenaha-Tucannon Wilderness Area are currently protected by the Wilderness designation. These streams should continue to be protected. Degraded reaches throughout the Subbasin should be protected from further degradation.

Tenmile-Couse Subbasin

Although habitat conditions in this Subbasin are generally poor to fair, steelhead/rainbow trout are present in both watersheds. Any remaining functioning patches of habitat should be protected. Degraded reaches should be protected from further degradation.

Asotin Creek Subbasin

The best remaining salmonid habitat in the Subbasin is located along the North Fork Asotin Creek, South Fork Asotin Creek, and upper George Creek. Steelhead/rainbow trout and bull trout are present in the North Fork. George Creek supports a steelhead run and shows good potential for bull trout presence in the upper reaches. Salmonids are present throughout the Subbasin. Any remaining functioning patches of habitat on stream reaches not identified should be protected. Degraded reaches should be protected from further degradation.

Alpowa-Deadman Subbasin

Although habitat conditions in this Subbasin are generally poor to fair, some functional habitat remains. Patches of quality riparian vegetation are known to be present on Alpowa Creek near Robinson Canyon and in several places on North Deadman Creek. The riparian buffer along Alpowa Creek from Stember Creek downstream is rapidly regrowing. These patches of habitat should be protected. Steelhead/rainbow trout are present in Alpowa and Deadman Creeks and are presumed present in Meadow Creek. Degraded reaches should be protected from further degradation.

Tucannon Subbasin

Stream reaches in the Wenaha-Tucannon Wilderness Area are protected by virtue of the Wilderness designation. The majority of quality habitat is located in the upper watershed in state and federal ownership. Protection and/or enhancement of these areas should continue. Degraded reaches should be protected from further degradation.

Snake Subbasin

Although habitat conditions on tributary streams are generally poor to fair, steelhead/rainbow trout are present. Any remaining functional habitat should be protected. Degraded reaches should be protected from further degradation.

Palouse River below Palouse Falls

This reach is largely protected by the relative inaccessibility of the surrounding canyon.

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APPENDIX A: GLOSSARY

Adfluvial: Life history strategy in which adult fish spawn and juveniles subsequently rear in streams, but migrate to lakes for feeding as subadults and adults. Compare to *fluvial*.

Aggradation: The geologic process of filling and raising the level of the streambed or floodplain by deposition of material eroded and transported from other areas.

Anadromous fish: Species that are hatched in freshwater, mature in saltwater, and return to freshwater to spawn.

Aquifer: Water-bearing rock formation or other subsurface layer.

Basin: The area of land that drains water, sediment and dissolved materials to a common point along a stream channel.

Biological Diversity (biodiversity): Variety and variability among living organisms and the ecological complexes in which they occur; encompasses different ecosystems, species, and genes.

Biotic Integrity: Capability of supporting and maintaining a balanced, integrated, adaptive community of organisms having a species composition, diversity, and functional organization comparable to that of natural habitat of the region; a system's ability to generate and maintain adaptive biotic elements through natural evolutionary processes.

Braided stream: Stream that forms an interlacing network of branching and recombining channels separated by branch islands or channel bars.

Buffer: An area of intact vegetation maintained between human activities and a particular natural feature, such as a stream. The buffer reduces potential negative impacts by providing an area around the feature that is unaffected by this activity.

Carrying capacity: Maximum average number or biomass of organisms that can be sustained in a habitat over the long term. Usually refers to a particular species, but can be applied to more than one species.

Channelization: Straightening the meanders of a river; often accompanied by placing riprap or concrete along banks to stabilize the system.

Channelized stream: A stream that has been straightened, runs through pipes or revetments, or is otherwise artificially altered from its natural, meandering course.

Channel Stability: Tendency of a stream channel to remain within its existing location and alignment.

Check dams: Series of small dams placed in gullies or small streams in an effort to control erosion. Commonly built during the 1900s.

Confluence: Joining.

Connectivity: Unbroken linkages in a landscape, often referred to in the context of mainstem connection with side-channels.

Critical Stock: A stock of fish experiencing production levels so low that permanent damage to the stock is likely or has already occurred.

Depressed Stock: A stock of fish whose production is below expected levels based on available habitat and natural variations in survival levels, but above the level where permanent damage to the stock is likely.

Debris torrent: Rapid movements of material, including sediment and woody debris, within a stream channel. Debris torrents frequently begin as debris slides on adjacent hillslopes.

Degradation: The lowering of the streambed or widening of the stream channel by erosion. The breakdown and removal of soil, rock, and organic debris.

Deposition: The settlement of material out of the water column and onto the streambed or floodplain.

Distributaries: Divergent channels of a stream typically occurring in a delta or estuary.

Diversity: Variation that occurs in plant and animal taxa (i.e., species composition), habitats, or ecosystems. See *species richness.*

Ecological restoration: Involves replacing lost or damaged biological elements (populations, species) and reestablishing ecological processes (dispersal, succession) at historical rates.

Ecosystem: Biological community together with the chemical and physical environment with which it interacts.

Ecosystem management: Management that integrates ecological relationships with sociopolitical values toward the general goal of protecting or returning ecosystem integrity over the long term.

Endangered Species Act: A 1973 Act of Congress that mandated that endangered and threatened species of fish, wildlife, and plants be protected and restored.

Endangered Species: Means any species which is in endanger of extinction throughout all or a significant portion of its range other than a species of the Class Insecta as determined by the Secretary to constitute a pest whose protection under would provide an overwhelming and overriding risk to man.

Escapement: Those fish that have survived all fisheries and will make up a spawning population.

Estuarine: A partly enclosed coastal body of water that has free connection to open sea, and within which seawater is measurably diluted by fresh river water.

Eutrophic: Water body rich in dissolved nutrients, photosynthetically productive, and often deficient in oxygen during warm periods. Compare *oligotrophic.*

Evolutionary Significant Unit (ESU): A definition of a species used by National Marine Fisheries Service (NMFS) in administering the Endangered Species Act. An ESU is a population (or group of populations) that is reproductively isolated from other conspecific population units, and (2) represents an important component in the evolutionary legacy of the species.

Extirpation: The elimination of a species from a particular local area.

Flood: An abrupt increase in water discharge; typically flows that overtop streambanks.

Floodplain: Lowland areas that are periodically inundated by the lateral overflow of streams or rivers.

Flow regime: Characteristics of stream discharge over time. Natural flow regime is the regime that occurred historically.

Fluvial: Pertaining to streams or rivers; also, organisms that migrate between main rivers and tributaries. Compare *adfluvia*l.

Gabion: Wire basket filled with stones, used to stabilize streambanks, control erosion, and divert stream flow.

Genetic Diversity Unit (GDU) is defined as: A group of genetically similar stocks that is genetically distinct from other such groups. The stocks typically exhibit similar life histories and occupy ecologically, geographically, and geologically similar habitats. A GDU may consist of a single stock.

Geomorphology: Study of the form and origins of surface features of the Earth.

Glides: Stream habitat having a slow, relatively shallow run of water with little or no surface turbulence.

Healthy Stock: A stock of fish experiencing production levels consistent with its available habitat and within the natural variations in survival for the stock.

Hydrograph: Chart of water levels over time.

Hydrology: Study of the properties, distribution, and effects of water on the Earth's surface, subsurface, and atmosphere.

Instream Flow Incremental Methodology: Flow modeling methodology used to determine incremental gains in fish habitat, for individual species, at different flow levels.

Intermittent stream: Stream that has interrupted flow or does not flow continuously. Compare *perennial strea*m.

Interspecific interactions: Interactions between different species.

Intraspecific interactions: Interactions within a species.

Iteroparous fish: Fish (such as steelhead) that are capable of repeat spawning. Spawned-out steelhead returning to the ocean are called "kelts." Compare to *semelparous*.

Kelt: A spawned-out fish (such as steelhead or cutthroat trout) returning to the ocean.

Kolk: An immense whirlpool like phenomenon formed in catastrophic floods flows. This phenomenon is equivalent to a tornado of water, while a whirlpool is comparable to one of the whirlwinds that are so common in southeast Washington.

Large Woody Debris (LWD): Large woody material that has fallen to the ground or into a stream. An important part of the structural diversity of streams. Usually refers to pieces at least 20 inches (51 cm) in diameter.

Limiting Factor: Single factor that limits a system or population from reaching its highest potential.

Macroinvertebrates: Invertebrates large enough to be seen with the naked eye (e.g., most aquatic insects, snails, and amphipods).

Mass failure: Movement of aggregates of soil, rock and vegetation down slope in response to gravity.

Native: Occurring naturally in a habitat or region; not introduced by humans.

Non-Point Source Pollution: Polluted runoff from sources that cannot be defined as discrete points, such as areas of timber harvesting, surface mining, agriculture, and livestock grazing.

Parr: Young trout or salmon actively feeding in freshwater; usually refers to young anadromous salmonids before they migrate to the sea. See *smol*t.

Piscivorous: Feeding habitat that includes consumption of fish.

Plunge pool: Basin scoured out by vertically falling water.

Push-up dam: A gravel dam (constructed with a bull dozer or backhoe) in the stream channel to deepen and direct water into irrigation diversion canals.

Rain-on-snow events: The rapid melting of snow as a result of rainfall and warming ambient air temperatures. The combined effect of rainfall and snow melt can cause high overland stream flows resulting in severe hillslope and channel erosion.

Rearing habitat: Areas required for the successful survival to adulthood by young animals.

Recovery: The return of an ecosystem to a defined condition after a disturbance.

Redds: Nests made in gravel (particularly by salmonids); consisting of a depression that is created and then covered.

Resident fish: Fish species that complete their entire life cycle in the same geographic area. All lifestages are found in the same habitat. In contrast, anadromous, adfluvial, and fluvial fish lifestages are found in different habitats.

Residual pool depth: The depth of a pool if it is isolated within a dry streambed. Visualize a pool scoured in the streambed. There is water flowing over the streambed upstream and downstream and filling the pool. Now stop the flow of water. Residual pool depth is the depth of water remaining in the isolated pool after the flow of water is stopped.

Riffle: Stream habitat having a broken or choppy surface (white water), moderate or swift current, and shallow depth.

Riparian: Type of wetland transition zone between aquatic habitats and upland areas. Typically, lush vegetation along a stream or river.

Riprap: Large rocks, broken concrete, or other structure used to stabilize streambanks and other slopes.

Rootwad: Exposed root system of an uprooted or washed-out tree.

SASSI: Salmon and Steelhead Stock Inventory.

SSHIAP: The Salmon and Steelhead Habitat Inventory and Assessment Project directed by the Northwest Indian Fisheries Commission.

Salmonid: Fish of the family salmonidae, including salmon, trout, and char.

Salmon: All species of the genus Oncorhynchus (includes chinook, coho, chum, pink, sockeye, rainbow/steelhead trout, and cutthroat trout).

Sediment: Material carried in suspension by water, which will eventually settle to the bottom.

Semelparous: Fish (such as the five species of Pacific Salmon that occur in Washington) that spawn only once, then die. Compare with *iteroparous*.

Side channel: A portion of an active channel that does not carry the bulk of stream flow. Side channels may carry water only during high flows, but are still considered part of the total active channel.

Sinuosity: Degree to which a stream channel curves or meanders laterally across the land surface.

Slope stability: The degree to which a slope resists the downward pull of gravity.

Smolt: Juvenile salmon migrating seaward; a young anadromous trout, salmon, or char undergoing physiological changes that will allow it to change from life in freshwater to life in the sea.

Stock: Group of fish that is genetically self-sustaining and isolated geographically or temporally during reproduction. Generally, a local population of fish. More specifically, a local population –

especially that of salmon, steelhead (rainbow trout), or other anadromous fish – that originate from specific watersheds as juveniles and generally return to their birth stream to spawn as adults.

Stream reach: Section of a stream between two points.

Subbasin: One of the smaller watersheds that combine to form a larger watershed.

Thalweg: Portion of a stream or river with deepest water and greatest flow.

Toe width: A method used to estimate instream flows necessary to provide habitat for salmon and steelhead. It was developed in the 1970s in western Washington by the U.S. Geological Survey (USGS), in cooperation with the Washington Department of Fisheries (WDF) and the Washington Department of Game (WDG). The method is based on statistical regressions of habitat, as measured in pilot studies based on actual fish habitat selection, on stream channel widths measured between the toes of the banks. Toes of the bank in riffle areas are indicated by change in cross-section slope, change in substrate, and sometimes by vegetation change. The toe width (usually an average of multiple measurements) is plugged into formulas for juveniles and spawners of different species of salmon and steelhead.

Watershed: Entire area that contributes both surface and underground water to a particular lake or river.

Watershed rehabilitation: Used primarily to indicate improvement of watershed condition or certain habitats within the watershed. Compare *watershed restoratio*n.

Watershed restoration: Reestablishing the structure and function of an ecosystem, including its natural diversity; a comprehensive, long-term program to return watershed health, riparian ecosystems, and fish habitats to a close approximation of their condition prior to human disturbance.

Watershed-scale approach: Consideration of the entire watershed in a project or plan.

Weir: Device across a stream to divert fish into a trap or to raise the water level or divert its flow. Also a notch or depression in a dam or other water barrier through which the flow of water is measured or regulated.

Wild Stock: A stock that is sustained by natural spawning and rearing in the natural habitat.

APPENDIX B: MAPS